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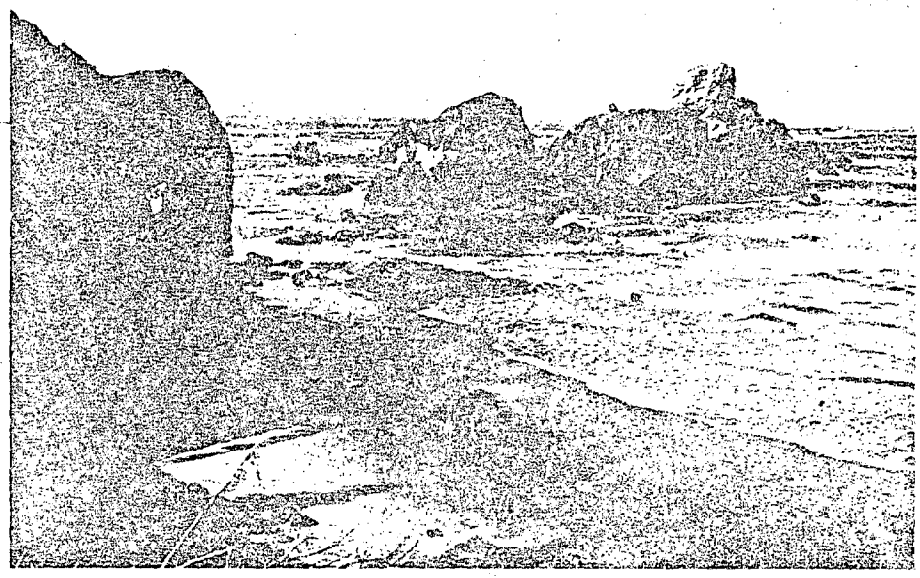
NATIONAL SHORELINE STUDY



INVENTORY REPORT
COLUMBIA-NORTH PACIFIC REGION
WASHINGTON AND OREGON

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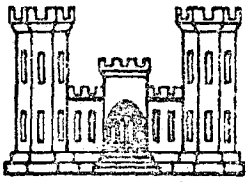

U.S. ARMY CORPS OF ENGINEERS
NORTH PACIFIC DIVISION

AUGUST 1971

The National Shoreline Study

How will the shore be used?

SEE

SHORE MANAGEMENT GUIDELINES

What is its condition?

SEE

REGIONAL INVENTORY REPORTS

What can be done?

to preserve or enhance the shore,

by using -

Engineering techniques

SEE

SHORE PROTECTION GUIDELINES
REGIONAL INVENTORY REPORTS

Management techniques

SEE

SHORE MANAGEMENT GUIDELINES

In 1968, the 90th Congress authorized this National appraisal of shore erosion and shore protection needs. This National Shoreline Study and the existing Federal shore protection programs recognize beach and shore erosion as problems for all levels of Government and all citizens. To satisfy the purposes of the authorizing legislation, a family of 12 related reports has been published. All are available to concerned individuals and organizations in and out of Government.

REGIONAL INVENTORY REPORTS (one for each of the 9 major drainage areas) assess the nature and extent of erosion; develop conceptual plans for needed shore protection; develop general order-of-magnitude estimates of cost for the selected shore protection; and identify shore owners.

SHORE PROTECTION GUIDELINES describe typical erosion control measures and present examples of shore protection facilities, and present criteria for planning shore protection programs.

SHORE MANAGEMENT GUIDELINES provide information to assist decision makers to develop and implement shore management programs.

REPORT ON THE NATIONAL SHORELINE STUDY, addressed to the Congress, summarizes the findings of the study and recommends priorities among serious problem areas for action to stop erosion.

NATIONAL SHORELINE STUDY

INVENTORY REPORT

COLUMBIA-NORTH PACIFIC REGION

WASHINGTON AND OREGON

U.S. ARMY CORPS OF ENGINEERS
NORTH PACIFIC DIVISION
210 Custom House
Portland, Oregon 97209

SEATTLE DISTRICT
1519 Alaskan Way, South
Seattle, Washington 93134

PORTLAND DISTRICT
Post Office Box 2946
Portland, Oregon 97208

AUGUST 1971

NATIONAL SHORELINE STUDY

INVENTORY REPORT
COLUMBIA - NORTH PACIFIC REGION
WASHINGTON AND OREGON

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NATIONAL SHORELINE STUDY

COLUMBIA-NORTH PACIFIC REGIONAL INVENTORY REPORT

PART I INTRODUCTION

1. AUTHORITY

This report was prepared under the authority of Section 106 of the 1968 River and Harbor Act (Public Law 90-483) approved 13 August 1968 and quoted below:

"SEC. 106. (a) The Chief of Engineers, Department of the Army, under the direction of the Secretary of the Army, shall make an appraisal investigation and study, including a review of any previous relevant studies and reports, of the Atlantic, Gulf, and Pacific coasts of the United States, the coasts of Puerto Rico and the Virgin Islands, and the shorelines of the Great Lakes, including estuaries and bays thereof, for the purpose of (1) determining areas along such coasts and shorelines where significant erosion occurs; (2) identifying those areas where erosion presents a serious problem because the rate of erosion, considered in conjunction with economic, industrial, recreational, agricultural, navigational, demographic, ecological, and other relevant factors, indicates that action to halt such erosion may be justified; (3) describing generally the most suitable type of remedial action for those areas that have a serious erosion problem; (4) providing preliminary cost estimates for such remedial action; (5) recommending priorities among the serious problem areas for action to stop erosion; (6) providing State and local authorities with information and recommendations to assist the creation and inplementation of State and local coast and shoreline erosion programs; (7) developing recommended guidelines for land use regulation in coastal areas taking into consideration all relevant factors; and (8) identifying coastal areas where title uncertainty exists. The Secretary of the Army shall submit to the Congress as soon as practicable, but not later than 3 years after the date of enactment of this Act, the results of such appraisal investigation and study, together with his recommendations. The views of concerned local, State, and Federal authorities and interests will be taken into account in making such appraisal investigation and study."

2. PURPOSE

The National Shoreline Study provides an overall comprehensive assessment of the beach and shore erosion problems confronting the Nation. The study is not intended to, and does not, develop specific projects for the protection of beaches and shores. It does, however, develop the information essential to assess the nature and extent of erosion problems and to formulate possible remedial action.

3. SCOPE

The National Shoreline study is broken into three classes: Shore Erosion Inventories; Shore Protection Guidelines; and Shore Management Guidelines. A separate report has been prepared for each of these classes.

This report presents an inventory of the physical characteristics, historical changes, and ownership and use of the coastal shorelines of the States of Washington and Oregon, including major bays and estuaries. (See figure 1.) The historic changes studied relate to erosion produced by wave and tidal phenomenon. The reports on protection guidelines and management guidelines were prepared and published by the Coastal Engineering Research Center, Corps of Engineers, and the Office, Chief of Engineers, respectively. The protection guidelines report presents typical protective structures, general design criteria, typical cost estimates for various areas, and examples of shore protection projects. The management guidelines report includes reference material on multiple uses of the shore, principles of comprehensive planning, zoning, insurance and other nonstructural alternatives. A summary report submitted to Congress summarizes the regional inventories and estimates of cost for erosion control measures and recommends categories of priorities and broad national goals and objectives of long-range comprehensive planning for the shoreline.

In presenting certain protective measures, the intent of this regional inventory report is to provide only a general guideline as to what measures would be suitable if protection of selected reaches of the shoreline is desired. No attempt has been made to compute detailed benefits and costs or to recommend specific improvements. Preliminary cost estimates presented here are based on available order-of-magnitude information for various types of protection. If corrective action is desired, detailed studies of all relevant factors will be necessary.

4. SOURCE OF DATA

In preparing the Columbia-North Pacific Regional Inventory Report for the National Shoreline Study maximum use was made of aerial photographs, existing Federal, State and county information and maps, and existing reports and materials on file in the Seattle and Portland Districts of the Corps of Engineers and shoreline data compiled for the Comprehensive Study of Water and Related Land Resources-Puget Sound and Adjacent Waters. These sources provided the bulk of information contained in this regional inventory report.

Areas of erosion were determined primarily from reports received from State and local agencies, from requests by local interests for assistance in alleviating erosion problems, from studies and surveillance programs conducted by the Corps of Engineers, and from study of aerial photographs.

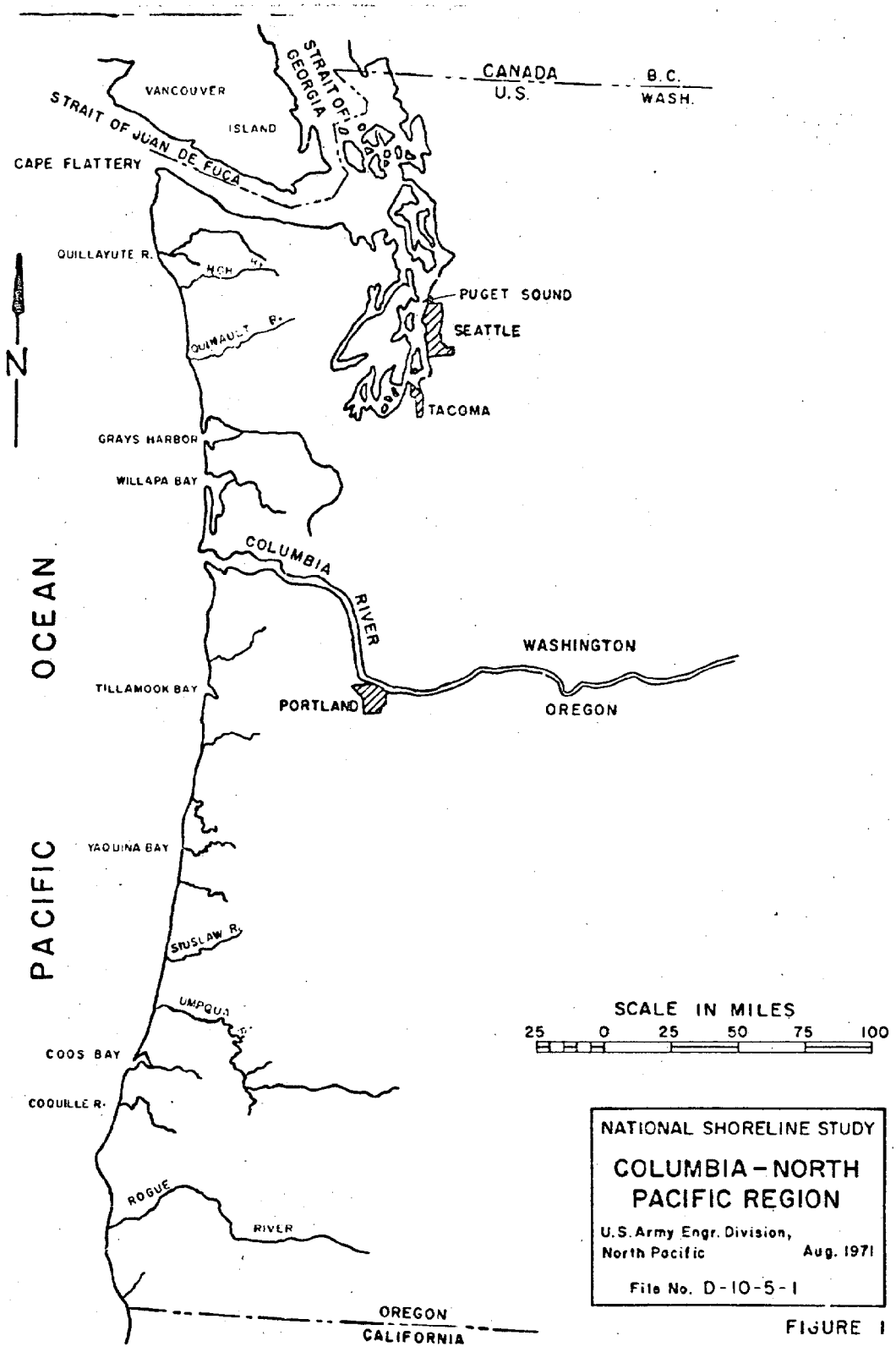

CANADA
U.S.
B.C.
WASH.
VANCOUVER
ISLAND
STRAIT OF GEORGIA
STRAIT OF JUAN DE FUCA
CAPE FLATTERY
QUILLAYUTE R.
HOH R.
QUINAULT R.
PUGET SOUND
SEATTLE
TACOMA
GRAYS HARBOR
WILLAPA BAY
COLUMBIA RIVER
WASHINGTON
OREGON
PORTLAND
TILLAMOOK BAY
PACIFIC OCEAN
YAQUINA BAY
SIUSLAW R.
UMPQUA R.
COOS BAY
COQUILLE R.
ROGUE RIVER
OREGON
CALIFORNIA
N
SCALE IN MILES
25 0 25 50 75 100
NATIONAL SHORELINE STUDY
COLUMBIA - NORTH PACIFIC REGION
U.S. Army Engr. Division, North Pacific
Aug. 1971
File No. D-10-5-1

FIGURE 1

Distances cited herein were determined by tracing, with a map measure, the shoreline on aerial photograph mosaics, navigation charts and county maps. Although effort was made to trace the irregularities of the shoreline, the distances are only approximate due to inherent errors in the method.

5. COORDINATION

Letters were sent to all Federal, State, and local governments, groups and individuals known to have interest in the shoreline, requesting their assistance in quantifying the characteristics, historic changes, ownership and use of the shoreline. Several press releases were made in attempts to involve the public. Information supplied through this coordination effort were incorporated into the first draft of the inventory report. Comments on the draft report were requested from those agencies, groups and individuals previously supplying information. These comments were incorporated into this final report. Contributors to this inventory report are listed below in table 1.

6. DESCRIPTIVE TERMS OF SHORELINE CONFIGURATION

a. Beach. The area of unconsolidated material between the low waterline and the extreme high waterline.

b. Rocky Coast. A shoreline comprising rocky headlands with relatively no beaches. Photo No. 1 shows typical rocky coast in Oregon and Washington.

c. Estuaries or Bays. A tidal inlet formed by the mouth of a river meeting the sea.

7. EXPLANATION OF TERMS USED FOR SHORE CLASSIFICATION

a. Physical Characteristics. Physical characteristics of the Washington and Oregon shoreline are shown on the "A" plates of this report.

(1) Shoreline With Beach. The zone of unconsolidated material that extends landward from the low waterline to the line of permanent vegetation, usually the effective limit of storm waves. Most of the Washington and Oregon Pacific Coast shoreline with beach consists of sand. The beaches of bays, inlets, estuaries and Puget Sound consist of sand, gravel and mud.

(2) Shore Without Beach. Shoreline without beach consists of rocky coastlines, marsh, bulkheads and revetments without a zone of unconsolidated material between the low waterline and the extreme high waterline.

b. Historical Shore Changes. Historic changes of Washington and Oregon shorelines are shown on the "A" plates of this report. A

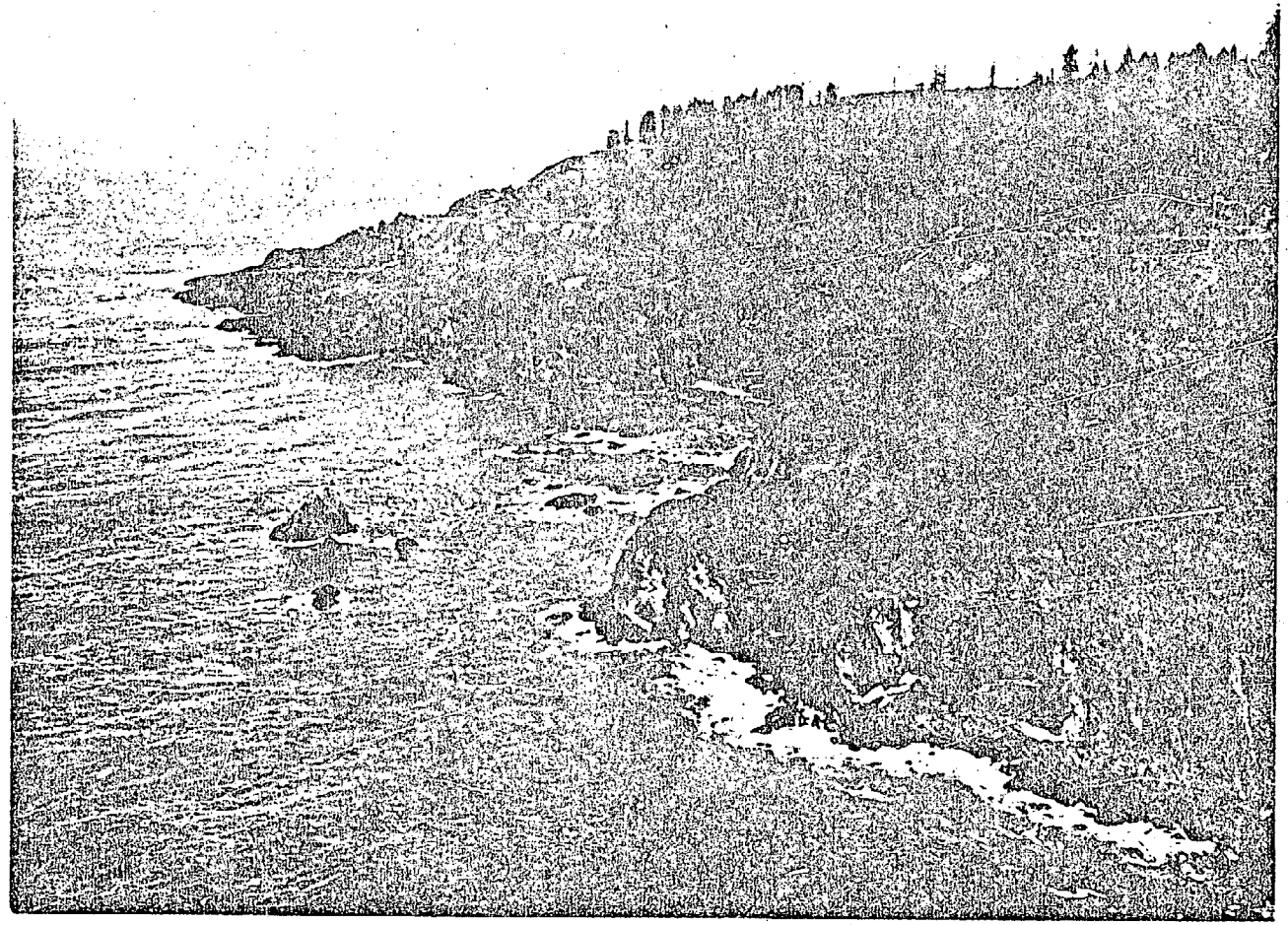


PHOTO 1. TYPICAL ROCKY COAST - WASHINGTON AND OREGON

TABLE 1

COLUMBIA-NORTH PACIFIC REGIONAL INVENTORY REPORT

CONTRIBUTORS

FEDERAL AGENCIES

Department of Agriculture
- Soil Conservation Service
- Forest Service

Department of Commerce
- National Marine Fisheries Service
- National Ocean Survey

Department of Defense
- U.S. Navy

Department of Housing and Urban Development
- Region X, Office of Metropolitan Planning and Development

Department of Interior
- Bureau of Indian Affairs
- Bureau of Land Management
- Bureau of Outdoor Recreation
- Bureau of Sport Fisheries and Wildlife
- Geological Survey
- National Park Service

Department of Transportation
- U.S. Coast Guard

Environmental Protection Agency
- Federal Water Quality Administration

STATE OF OREGON

Department of Highways
- Parks and Recreation Division

Department of Transportation
- Port Division

TABLE 1 (Cont'd)

STATE OF WASHINGTON

Department of Highways

Department of Natural Resources

Parks and Recreation Commission

LOCAL AGENCIES

Clallum County
Grays Harbor County
Island County
Jefferson County
King County
Kitsap County
Pacific County
Pierce County
San Juan County
Skagit County
Snohomish County
Thurston County
Whatcom County
Port of Bellingham
Port of Coupeville
Port of Grays Harbor
Port of Keyport
Port of Olympia
Port of Nehalem
Port of Newport
Port of Shelton
Port of Skagit County
Port of Willapa Bay
City of Seattle
Municipality of Metropolitan Seattle (METRO)

OTHERS

Puget Sound Governmental Conference
University of Washington
Western Washington State College
Wolf Bauer
Edward Berg

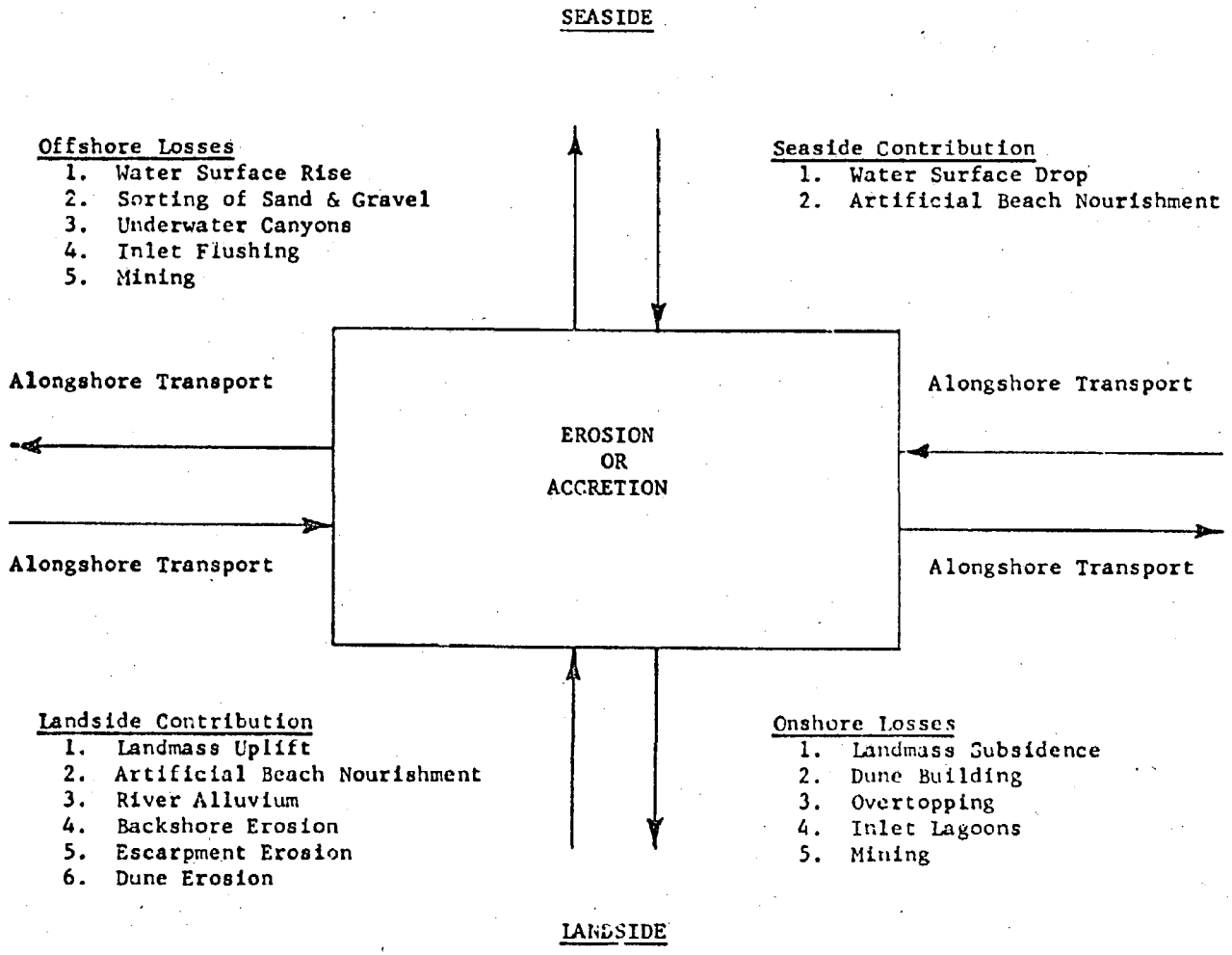
schematic of factors contributing to shoreline changes is shown on figure 2. The nature and rate of shoreline changes are governed by climatic, oceanographic, anf geographic factors.

(1) Erosion. The wearing away of land by the action of natural forces; for the purposes of this inventory report, the carrying away of beach and upland material by wave action, tidal currents, or littoral currents. An eroding condition has more material leaving the system than is entering. Transitory changes of the Washington and Oregon shoreline occur frequently; sand beaches build up during the summer months but are stripped away during the winter. Long-term changes are often too slow to be reliably measured. Erosion of the headlands is continuous and in some instances fairly rapid, as is the seaward growth of the beaches in some localities. Because of the lack of development along much of the Washington and Oregon shoreline, erosion has not caused a significant economic impact and little attention has been given to the problem. Very few records of volumetric changes or rates of change exist, and historical photos or charts by which comparison could be made are likewise lacking.

(2) Critical Erosion. Erosion by wave action, tidal or littoral currents presents a serious problem because the rate of erosion, considered in conjunction with economic, industrial, recreational, agricultural, navigational, demographic, ecological and other relevant factors indicates that action to halt such erosion may be justified. However, existing data on many of the factors are insufficient to quantify this decision. Major studies beyond the scope of the National Shoreline Study are required for definitive answers. Structural measures including seawalls, revetments, bulkheads, groin systems and beach nourishment are usually considered for protecting the shoreline from erosion. However, structural measures taken to solve the problem in one area could transfer the problem elsewhere. Management, zoning or acquisition of a public easement along the shoreline could be a logical means of preventing economic and other losses in some areas. These nonstructural alternatives should be investigated as part of any in-depth study of erosion areas.

(3) Noncritical Erosion. Erosion by wave action, tidal or littoral currents does not present a serious problem because the rate of erosion in conjunction with all relevant factors indicates that structural measures may not be justified and/or that management to prevent or minimize adverse effects may be more appropriate than action to halt erosion.

(4) No Erosion. Shoreline is stable or is accreting either naturally or through the efforts of man. In a stable condition the material entering the system is equal to the material leaving the system. Any accreting condition has more material entering the system than is leaving.



FACTORS CONTRIBUTING TO SHORELINE CHANGES

FIGURE 2

c. Shore Ownership. For the purposes of this inventory report, shore ownership considers the land adjacent to and landward of the 1970 high water line. Erosion is a landward movement of this line and these ownerships are of prime importance in evaluating the relevant factors contributing to cri ical or noncritical erosion. Generally, the area between the low waterline and the high waterline is owned, controlled or managed by the states. In some areas, especially in bays and estuaries, these lands have been sold or leased by the states for commercial or private purposes. Shore ownerships are shown on the "B" plates.

(1) Federal. Land owned by the Federal Government, such as parks, wildlife refuge areas, military installations and navigation facilities.

(2) Public (Non-Federal). Land owned by State, county and municipal governments and port districts. These lands include parks, and navigation installations and waterway and fisherman access areas.

(3) Private. Land owned by private individuals and groups, for commercial, industrial and residential purposes. Indian reservations have been included in this category.

d. Shore Use. Shore use in this report considers the land adjacent to and landward of the 1970 high waterline. Erosion is a landward movement of this line and use of these lands is important in evaluating the relevant factors contributing to critical or noncritical erosion. Generally, the area between the low water and high waterline in the States of Washington and Oregon is used for recreation purposes including hiking, beachcombing, clam digging, surf fishing and sunbathing. Even isolated beaches have some recreation use, primarily hiking. Access to these isolated beaches is from adjacent beaches, across uplands or by water. Shore uses are shown on the "B" plates.

(1) Recreational-Public. This includes public usage of Federal, State, county and municipal parks and boat launch ramps and moorage facilities for recreational purposes.

(2) Recreational-Private. This includes privately developed parks, resort and moorage facilities used for recreational purposes.

(3) Non-Recreational Development. This includes all use for purposes other than recreation such as commercial, industrial and residential developments and port and harbor facilities.

(4) Undeveloped. This consists primarily of isolated shoreline and high bank beach front making development difficult.

8. FEDERAL PROGRAMS

The legislation establishing the existing Federal shore protection and beach restoration programs declares it to be "the policy of the United States to assist in the construction, but not the maintenance, of works for the improvement and protection against erosion by waves and currents of the shores of the United States, its territories and possessions." In its present form, the legislation spells out the conditions for, and the extent of, Federal participation. Basically, it relates Federal participation to public benefits and requires the active participation of sponsoring local interests. Under this concept, Federal participation is greatest where the shore areas are publicly owned and appropriate facilities to encourage full public use are provided as much as 70 percent of the construction cost can be borne by the Federal Government in such cases. Where the shore area to be protected is privately owned and there is no public use, no Federal funds can be provided. Between these extremes, Federal participation in providing protection is proportional to public use and benefit. The remaining costs are borne by the sponsoring local interests.

By various Public Laws, the Congress has directed the Chief of Engineers to carry out the policies and programs established to protect and restore the Nation's shorelines. Under these legislative authorities, the Corps of Engineers conducts research into the causes of beach erosion, investigates and studies specific beach erosion problems and constructs shoreline protection and beach restoration projects.

Shore protection and beach restoration programs include projects specifically and individually authorized by Congress, and projects for which individual authorization by Congress is not required. The latter program is limited to projects for which the Federal share of the construction cost will not exceed $1,000,000. These programs will be referred to as the regular project program and the small project program.

Shore protection and beach restoration projects are initiated by requests from local interests. Publicly owned shores subject to erosion are eligible for Federal assistance; privately owned shores may be eligible for Federal assistance if there is public benefit such as that arising from public use. Parties desiring information, advice, and assistance in combating beach erosion should act through and in cooperation with the State, county, or city agency concerned with beach and shore use and management. Consultation with the appropriate District or Division Engineer should then be held to explore the eligibility and applicability of Federal programs. The regular program for beach erosion studies is authorized by Congress either by a resolution approved by the Public Works Committee of the Senate or

the House of Representatives or in a River and Harbor Act enacted by the Congress. If the small-project program is applicable, the Chief of Engineers can authorize the study.

Investigations and studies are made to determine whether a project is justified and, if so, whether its construction is feasible. One of the early concerns of the Engineer Officer directing the study is to ascertain the desires and opinions of all parties affected by, or having an interest in, the protection, improvement, and use of the shore area concerned. To this end, he holds public meetings and workshops during the course of the study. The study thoroughly examines the problem and alternative solutions along with the pros and cons. After careful analysis of the impacts of all applicable remedial measures on the erosion problem, other shore areas, the regimen of the coastal waters, shore processes, marine life, ecological values, and shore uses, a general plan for shore protection and beach restoration is devised. If comparisons of the costs of construction and the benefits resulting from the construction show the project to be a sound and prudent public investment, and if the local sponsoring agency affirms willingness and ability to provide the required cooperation, the report on the study recommends adoption of the project. Reports are reviewed by the Board of Engineers for Rivers and Harbors and the Chief of Engineers, and circulated for comments of the Governors of affected States, State and local agencies, and all interested Federal agencies.

As soon as a project is authorized and funded under either the regular or the small-project programs, the responsible District Engineer carries out the detailed engineering work essential to construction and prepares construction drawings and specifications. Contractors submit bids based on these drawings and specifications and a construction contract is awarded to the successful bidder. The District Engineer continues to consult and coordinate with the local sponsoring agency while engineering and construction are underway. Upon completion, the protective works are turned over to the sponsoring local interests for operation and maintenance in accordance with the existing legislation.

Further information on assistance by the Corps of Engineers in shore protection is contained in a publication, "Shore Protection Program," by the Office, Chief of Engineers, July 1970. Copies of this publication can be obtained from Division or District Engineers.

9. EROSION CONTROL METHODS

Methods to alleviate shoreline erosion problems can be structural, nonstructural, or a combination of the two. Seawalls, bulkheads, groins, revetments, and artificial beach nourishment are examples of structural methods. Nonstructural alternatives involve a zoning or management program which controls the amount and type of shoreline development.

Shore protection works constructed in Washington and Oregon have consisted primarily of rock revetments or bulkheads. Highway facilities most often are protected by this method. However, these types of structural measures sometimes are not compatible with recreational use of the shoreline. In such cases beach restoration might be a more suitable alternative for much of Washington's and Oregon's shoreline. The restoration would be accomplished by periodically placing sand on the beach. In some instances it may be necessary to use groins in conjunction with the beach nourishment to stabilize the beach. Revetment or bulkheads could be effectively used where recreational use of the shore is not a significant factor. These structural-type methods could probably be best utilized within bays and estuaries where there is extensive commercial development. Structural protection against erosion of headlands would be extremely difficult and very costly as there is normally deep water adjacent to shore. In these situations zoning or a shore management plan might be utilized. The zoning or shore management plan obviously does not prevent the erosion processes but it does lessen its adverse impact. There is some validity to a zoning or management policy as disruption of the erosion process may cut off the supply of sand which naturally feeds the beach zone. In any case the determination of a suitable method for controlling erosion should consider the primary uses and characteristics, both demographic and ecological, as well as economic factors of the shoreline.

10. ESTIMATED COSTS

Costs of remedial action will vary greatly from one locality to another, depending upon the type of action taken, the remoteness of the site, availability of construction materials, extent of the shoreline to be protected, degree of exposure, and other factors. The cost of beach nourishment, for example, could vary over a wide range. In some areas a dredge could work inside a relatively protected bay or estuary and pump sand into the shoreline with little difficulty. However, in other instances it might require a seagoing dredge to move material close to shore in conjunction with a secondary or even tertiary system to move the sand to the shore and distribute it along the beach. Initial cost of beach nourishment is presently estimated to range from $250,000 to $750,000 per mile. Periodic replenishment might be necessary. Revetment works exposed to large ocean waves are presently estimated to cost about $750,000 to $2,000,000 per mile. Revetment works in protected waters are presently estimated to cost about $250,000 to $1,000,000 per mile.

PART 2 - THE WASHINGTON SHORELINE

11. GENERAL

The inventory for the State of Washington encompasses all mainland and inland shoreline in Puget Sound and the Strait of Georgia south of the Canadian border; all shoreline along the Strait of Juan de Fuca from Point Wilson west to Cape Flattery; all Pacific Coast and estuary shoreline from Cape Flattery south to the Columbia River; and the north shoreline of the Columbia River from its mouth east to Harrington Point (see plate 1). The Columbia River, Willapa Bay and Grays Harbor estuaries are the most distinctive shoreline features along the Pacific Ocean shoreline.

12. PHYSICAL CHARACTERISTICS

Washington has 2,337 miles of shoreline comprising 157 miles along the Pacific Ocean, 144 miles along the Strait of Juan de Fuca, 89 miles in Grays Harbor, 129 miles in Willapa Bay, 34 miles on the Columbia River and 1,784 miles along the inland waters of Puget Sound and the Strait of Georgia. This measurement includes the shorelines of 172 significant islands of the San Juan Archipelago. Of Washington's 2,337 miles of shoreline, 1,847 miles have beach and 490 miles are without beach but consist of rocky headlands, marsh areas, bulkheads and revetments.

Classification of Washington's ocean and bay/estuary shoreline is summarized in table 2. For this report ocean exposure includes the Pacific Ocean and the Strait of Juan de Fuca and bay/estuary exposure includes the inland waters of Puget Sound and the Strait of Georgia and the estuaries of Grays Harbor, Willapa Bay and the Columbia River.

Much of the 1,784 miles of shoreline in Puget Sound and the Strait of Georgia are irregular with narrow beaches, many rocky points, high bluffs and a few shallow bays. Photo 2 shows a typical Puget Sound shoreline. The shoreline is generally forested to water's edge or to the top of the bluffs. The urbanized areas generally occupy low-lying portions of the shoreline. Many deep-water ports are situated in these urban areas taking advantage of the protected salt waters of Puget Sound. Several major features comprise the physical characteristics of Puget Sound. One is Hood Canal, a long L-shaped arm extending deep into the Olympic Peninsula. Another is the 172 significant islands of the San Juan Archipelago. About 16 other islands are situated around Puget Sound, one of which is Whidbey Island, one of the largest islands in the contiguous United States. Due to their proximity to large population centers, most of the beach areas in Puget Sound and the Strait of Georgia are utilized for recreation purposes.

TABLE 2
CLASSIFICATION SUMMARY - WASHINGTON

CLASSIFICATIONS	OCEAN SHORELINE EXPOSURE 1/	BAY/ESTUARY SHORELINE EXPOSURE 2/	TOTAL WASHINGTON SHORELINE EXPOSURE
MILES OF SHORELINE	301.0 Miles	2036.0 Miles	2337.0 Miles
PHYSICAL CHARACTERISTICS			
Shoreline without beach	65.0	425.0	490.0
Shoreline with beach	236.0	1611.0	1847.0
HISTORICAL SHORE CHANGES			
Critical Erosion	1.9	5.4	7.3
Noncritical erosion	34.0	57.0	91.0
No erosion	265.1	1973.6	2238.7
SHORELINE OWNERSHIP			
Federal	61.0	94.0	155.0
Public (Non-Federal)	10.0	97.0	107.0
Private	230.0	1845.0	2075.0
Uncertain	0.0	0.0	0.0
SHORE USE			
Recreational-public	83.0	64.0	147.0
Recreation-private	0.0	40.0	40.0
Nonrecreational development	6.0	71.0	77.0
Undeveloped	212.0	1861.0	2073.0

1/Pacific Ocean and Strait of Juan de Fuca.
2/Columbia River, Willapa Bay, Grays Harbor, Puget Sound, Strait of Georgia.

The 144 miles of shoreline along the exposed waters of the Strait of Juan de Fuca from Point Wilson to Cape Flattery are typically narrow beach backed up by steep high bluffs interpersed with many outcrops of rock. The major exceptions are Ediz Hook and Dungeness Spit near the eastern end of the Strait. West of Port Angeles the shoreline is quite rugged. Most of the land adjoining the Strait is tree-covered except for urbanized areas and farmland near Dungeness Spit.

The Pacific Ocean shoreline from Cape Flattery south to the Quinault River is quite rugged and rocky with high bluffs. The shoreline is interrupted with generally narrow beaches and small rivers. The adjacent uplands are heavily forested. From the Quinault River south to the Washington-Oregon border the shoreline generally consists of flat straight sandy beaches with dunes and grassland abutted by low-banks gently sloping upland. Grays Harbor, Willapa Bay and the Columbia River are major estuaries along the reach. U.S. Highway 101 generally parallels the Pacific Ocean shoreline.

13. HISTORIC SHORE CHANGES

The inventory of historical shore changes shows 98.3 miles of Washington shoreline that are eroding. Of this total 7.3 miles are in critical condition and 91.0 miles have a history of noncritical erosion. The remaining 2,238.7 miles of shore frontage are either stable or accreting (see table 2). During the period of historical record erosion has been severe at the entrances to Willapa Bay (Cape Shoalwater and Toke Point) and Grays Harbor (Point Chehalis). The rocky shoreline along the northern Washington Coast is stable with only isolated erosion areas, such as at the mouth of Quillayute River. The shoreline along the Strait of Juan de Fuca is also relatively stable except at Ediz Hook where serious erosion is occurring. Only relatively minor erosion problems in isolated locations exist within the protected waters of the Puget Sound area. The most important of these is erosion of the shoreline at Titlow Beach near the city of Tacoma.

14. LITTORAL DRIFT

Directions of wave action and littoral drift of sediments shift seasonally with Pacific Ocean storms. Very little data are available concerning the net direction of littoral transport for Washington's Pacific Ocean shoreline. While the most severe wave action is from the southwest, and waves from the northwest prevail for a longer period of time, the predominant littoral transport of sediments could be assumed to be from south to north. The Department of Oceanography of the University of Washington has offshore data on radionuclide distribution and seadrifter distribution which indicate a northerly offshore flow. Analysis of offshore sediment material indicates a southern origin. However, there is a net loss of near-shore sediments associated with the waves from the southwest, and a

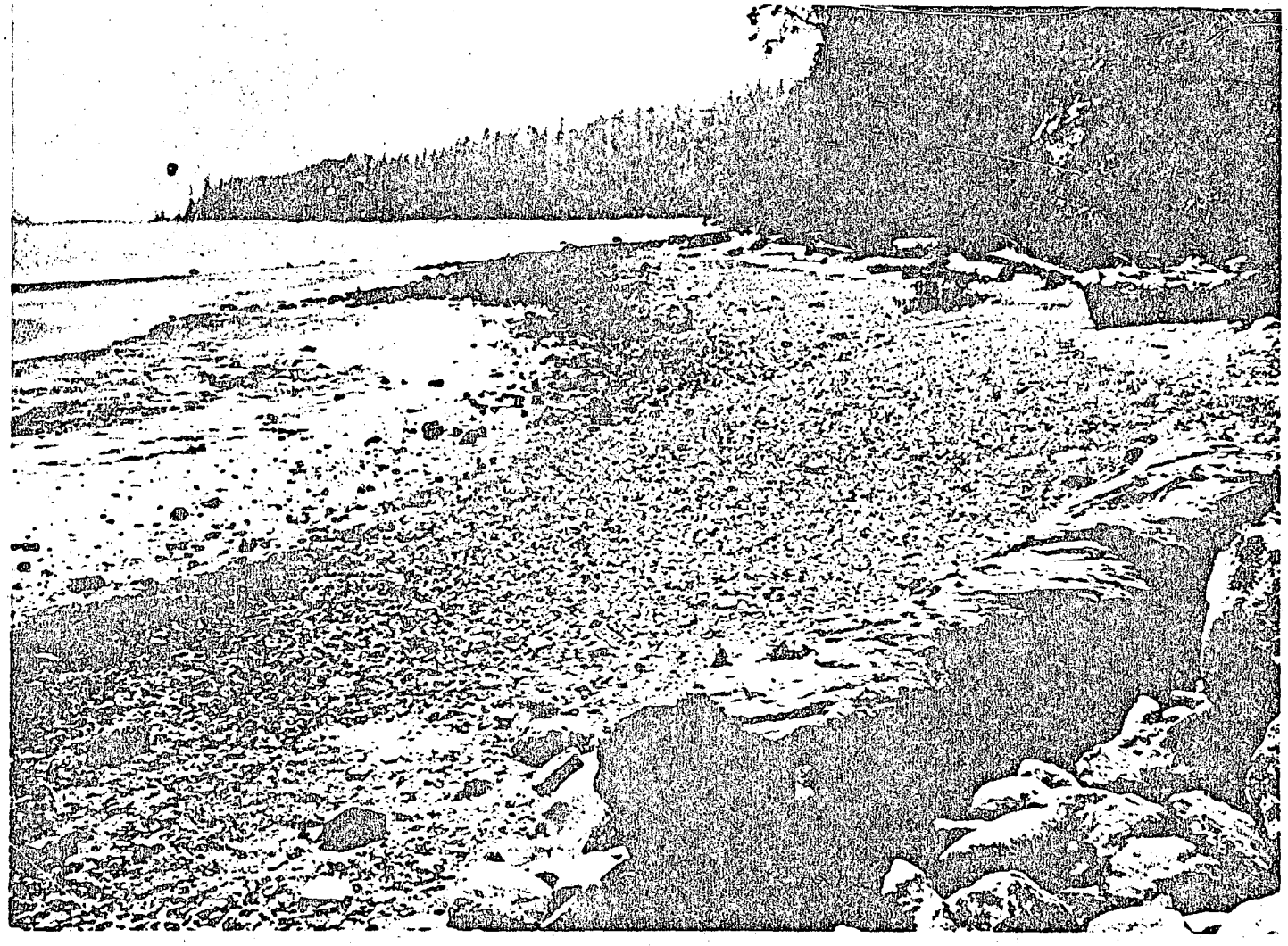


PHOTO 2. TYPICAL PUGET SOUND SHORELINE. (Photo by Washington State Parks and Recreation Commission)

net gain of nearshore sediments associated with waves from the northwest. Rapid accretion of the shoreline on the northern side of the north jetties at the Columbia River and Grays Harbor indicates a predominant nearshore littoral transport of sediment from north to south.

Littoral movement along the Strait of Juan de Fuca is from west to east. Within Puget Sound and the Strait of Georgia and the Grays Harbor, Willapa Bay and Columbia River estuaries, littoral movement is localized. Wave action in these protected waters is greatly reduced, beaches are narrow and movement of material alongshore is generally not significant. The direction of littoral drift in these inland waters reverses with the changing seasons. More study is needed in connection with littoral drift prior to formulating plans for specific projects.

15. SHORE OWNERSHIP

About 2,075 miles of Washington's shoreline landward of the extreme high waterline are in private ownership. The Federal Government owns about 155 miles including the Olympic National Park and various wildlife refuge areas. Non-Federal public ownership totals 107 miles primarily State, county and city parks (see table 2). Some of the non-Federal public land is owned by various port districts and utilized for waterborne commerce facilities and small-boat moorage facilities. The State of Washington owns or controls most of the land seaward of the extreme high waterline. The State has sold some of these lands near urban areas. Ownerships landward of the extreme high waterline were inventoried because these lands have considerable economic importance in determining areas of critical erosion.

16. SHORE USE

The inventory of shoreline use includes the area landward of the extreme high waterline because usage of these lands is of primary importance in determining critical erosion areas. About 2,073 miles of Washington's shoreline are undeveloped because of its remoteness or because the high bank beach front makes access difficult. Public recreational use of about 147 miles of shoreline occurs in publicly owned parks and pleasure-boat moorage facilities and on Indian reservations listed as privately owned. Private recreational facilities totaling 40 miles consist of resort areas and privately owned pleasure-boat moorage facilities. About 77 miles of shoreline have noncreational development such as commercial and industrial areas. Private residential areas are grouped into noncreational development and undeveloped shore use depending on whether low-bank or high-bank waterfront is involved.

17. AUTHORIZED FEDERAL PROJECTS

Two Federal navigation projects constructed in Washington provide shoreline protection. A system of rock groins and a rock revetment

were built to prevent erosion of Point Chehalis near the mouth of Grays Harbor and at the same time add protection for Westhaven Cove at Westport. These measures at Point Chehalis are not entirely effective in preventing erosion. Shore protection was also a part of the Federal project at Neah Bay where a breakwater was built to protect the harbor. No Federal projects solely for shore protection have been constructed in Washington. However, numerous Federal navigation projects have been constructed. Table 3 lists the name, location and pertinent data regarding Federal navigation projects in Washington.

TABLE 3

AUTHORIZED FEDERAL PROJECTS - WASHINGTON

NAME	DESCRIPTION	STATUS
Anacortes Harbor, Washington	Capsante Waterway - dredging	Complete
	Small-Boat Basin - breakwaters	Complete
Bellingham Harbor, Washington	Squalicum Creek Waterway - dredging	Complete
	Whatcom Creek Waterway - dredging	Complete
	I and J Street Waterway - dredging	Complete
	Small-Boat Basin - breakwaters	Complete
Blaine Harbor, Washington	Small-Boat Basin - breakwaters	Complete
Columbia River at Baker Bay, Washington	Channel dredging	Complete
	Small-Boat Basin - breakwaters	Complete
Columbia River at Mouth, Washington and Oregon	Channel dredging - north, south and spur jetties	Complete

NAME	DESCRIPTION	STATUS
Columbia River between Chinook, Washington and the Head of Sand Island	Channel and moorage basin dredging	Complete
	Breakwaters	Complete
Deep River, Washington	Channel dredging	Complete
Edmonds Harbor, Washington	Small-Boat Basin - breakwater and channel maintenance only	Complete
Everett Harbor and Snohomish River, Washington	Channel dredging and training dike	Complete
	Training dike rehab and extension	Authorized
Grays Harbor and Chehalis River, Washington	North and South Jetty	Complete
	Bar and channel dredging	Complete
	Small-Boat Basin - breakwaters	Complete
Grays River, Washington	Removal of snags and other obstructions	Complete
Hammersely Inlet, Washington	Channel dredging	Complete
Hoquiam River, Washington	Channel dredging	Complete
Kingston Harbor, Washington	Small-Boat Basin - breakwater	Complete
Lake Crocket, Whidbey Island, Washington	Mooring basin dredging and breakwater	Complete
Lake Washington Ship Canal, Seattle, Washington	Navigation lock and channel	Complete
Mats Mats Bay, Washington	Channel dredging	Complete
Neah Bay, Washington	Breakwater	Complete

NAME	DESCRIPTION	STATUS
Olympia Harbor, Washington	Channel and turning basin dredging	83% complete - 17% deferred for restudy
Port Angeles Harbor,	Small-Boat Basin - breakwater	Complete
Port Gamble, Washington	Channel dredging	Incomplete
Port Orchard Bay, Washington	Shoal removal	Not constructed
Port Townsend, Washington	Small-Boat Basin - breakwater	Complete
Puget Sound and its Tributary Waters, Washington	Removal of snags and shoals	Continuous
Quillayute River, Washington	Jetty and channel dredging	Complete
	Small-Boat Basin - training wall and dredging	Complete
Seattle Harbor, Washington	West Waterway - dredging	Complete
	East Waterway - dredging	Complete
	Duwamish Waterway - dredging	Complete
Shilshole Bay, Seattle, Washington	Small-Boat Basin - breakwaters and dredging	Complete
Skagit River, Washington	Provides for a reliable entrance channel by dikes, training walls and dredging	Incomplete
Swinomish Channel, Washington	Channel dredging	Complete
Tacoma Harbor, Washington	Hylebos Waterway - dredging	Complete
	City Waterway - dredging	Complete
	Puyallup Waterway - training walls	Complete
	Blair Waterway - dredging	Complete

NAME	DESCRIPTION	STATUS
Waterway connecting Port Townsend and Oak Bay, Washington	Channel dredging and jetties	Complete
Willapa River and Harbor and Naselle River, Washington	Bar and channel - dredging	Complete
	Tokeland Small-Boat Basin dredging	Complete
	Nahcotta Small Boat Basin breakwater	Complete
	Naselle River - removal of obstructions	Complete

18. AUTHORIZED FEDERAL SURVEY STUDIES

Several studies of beach erosion problems have been authorized for the shoreline of the State of Washington. Table 4 below lists the name, location and status of these beach erosion studies.

TABLE 4

BEACH EROSION STUDIES - WASHINGTON

Name	Location	Status
Ediz Hook, Washington	Strait of Juan de Fuca, Port Angeles	Underway
Titlow Beach, Tacoma, Washington	Puget Sound	Deferred pending completion of a small-boat harbor study at the same location.
Toke Point, Washington	Willapa Bay	Deferred pending completion of Willapa River and Harbor and Cape Shoalwater study.
Willapa River & Harbor, Washington, Cape Shoalwater, Pacific County, Washington	Willapa Bay	Feasibility study of erosion problems at Cape Shoalwater is underway.

19. ADDITIONAL STUDIES NEEDED

The authorized feasibility study of erosion problems at Cape Shoalwater is part of a feasibility study of navigation improvements at Willapa Bay. This feasibility study will determine the desirability of conducting detailed studies of Willapa Bay including Cape Shoalwater. These detailed studies would require model studies of the Willapa Bay estuary to assist in determining remedial measures for the navigation and beach erosion problems. Erosion control measures at Point Chehalis are being investigated under operation and maintenance authorities and are being evaluated in a model of the Grays Harbor estuary constructed for the authorized navigation study of Grays Harbor. Erosion at the mouth of the Quillayute River is being controlled by sand replenishment from Federal maintenance dredging of the river channel and a mooring basin.

20. WASHINGTON COUNTIES

The 2,337-mile Washington shoreline from the Canadian border to the Oregon border is briefly described and inventoried by Washington's 15 counties with shoreline. While the shoreline processes do not recognize political boundaries, remedial action for controlling erosion most likely would be accomplished by or through a local governmental body. County governments will also have valuable use for the inventory of their shorelines. A summary of county shoreline classifications is shown on table 5. Sections of Washington's shoreline are presented in plates 2 through 12. Physical characteristics and historic shore changes are classified on the "A" plates. Shore ownership and use are classified on the "B" plates.

TABLE 5
COUNTY CLASSIFICATION - WASHINGTON

COUNTY	LENGTH	PHYSICAL CHARACTERISTICS		HISTORICAL SHORE CHANGES			SHORELINE OWNERSHIP				SHORE USE			
	Miles of Shoreline	Shoreline with Beach	Shoreline Without Beach	Critical Erosion	Noncritical Erosion	No Erosion	Federal	Public (Non-Federal)	Private	Uncertain	Recreational-Public	Recreational-Private	Nonrecreational Development	Undeveloped
San Juan	359.0	218.0	141.0	0	12.3	346.7	4.4	9.1	345.5	0	7.7	0	1.0	350.3
Whatcom	102.0	74.5	27.5	0	3.3	98.7	1.1	11.2	89.7	0	8.9	0	5.0	88.1
Skagit	127.0	78.0	49.0	0	16.7	110.3	2.2	3.3	121.5	0	4.5	3.5	6.0	113.0
Island	194.0	188.0	6.0	0	3.3	190.7	13.4	8.9	171.7	0	5.6	3.5	1.0	183.9
Snohomish	43.0	18.5	24.5	0	1.1	41.9	0	2.2	40.8	0	1.1	0	15.0	26.9
King	113.0	98.5	14.5	0	3.3	109.7	2.2	12.2	98.6	0	6.7	0	14.0	92.3
Pierce	235.0	217.5	17.5	0.5	0	234.5	13.4	14.3	207.3	0	3.3	0	9.0	222.7
Thurston	90.0	82.5	7.5	0	0	90.0	0	3.3	86.7	0	1.1	0	4.0	84.9
Mason	174.0	168.0	6.0	0	0	174.0	0	5.5	168.5	0	3.3	22.7	1.0	147.0
Kitsap	211.0	201.0	10.0	0	0	211.0	11.0	8.9	191.1	0	4.5	0	4.0	202.5
Jefferson	194.0	184.0	10.0	0	13.3	180.7	35.4	3.3	155.3	0	15.6	2.2	2.0	174.2
Ocean	58.0	57.0	1.0	0	13.3	44.7	23.0	0	35.0	0	15.6	0	0	42.4
Estuary	136.0	127.0	9.0	0	0	136.0	12.4	3.3	120.3	0	0	2.2	2.0	131.8

TABLE 5 (Cont'd)
COUNTY CLASSIFICATION - WASHINGTON

COUNTY	LENGTH	PHYSICAL CHARACTERISTICS		HISTORICAL SHORE CHANGES			SHORELINE OWNERSHIP				SHORE USE			
	Miles of Shoreline	Shoreline with Beach	Shoreline without Beach	Critical Erosion	Noncritical Erosion	No Erosion	Federal	Public (Non-Federal)	Private	Uncertain	Recreational-Public	Recreational-Private	Nonrecreational Development	Undeveloped
Clallam	156.0	93.5	62.5	1.9	12.2	141.9	35.4	8.0	112.6	0	8.9	0	6.0	141.1
Grays Harbor	146.0	105.0	41.0	0.6	13.3	132.1	1.1	8.9	136.0	0	29.0	8.1	8.0	100.9
Ocean	57.0	56.0	1.0	0	8.5	48.5	0.2	1.0	55.8	0	29.0	0	0	28.0
Estuary	89.0	49.0	40.0	0.6	4.8	83.6	0.9	7.9	80.2	0	0	8.1	8.0	72.9
Pacific	185.0	112.0	73.0	4.3	11.1	169.6	35.4	7.9	141.7	0	46.8	0	1.0	137.2
Ocean	30.0	29.5	0.5	0	0	30.0	2.4	1.0	26.6	0	29.5	0	0	0.5
Estuary	155.0	82.5	72.5	4.3	11.1	139.6	33.0	6.9	115.1	0	17.3	0	1.0	136.7
Wahkiakum	8.0	8.0	0	0	1.1	6.9	0	0	8.0	0	0	0	0	8.0
TOTALS Washington State	2,337.0	1,847.0	490.0	7.3	91.0	2,238.7	155.0	107.0	2,075.0	0	147.0	40.0	77.0	2,073.0

SAN JUAN COUNTY

San Juan County is located at the junction of the Straits of Juan de Fuca and Georgia and Puget Sound (see plate 2). Its western boundary is British Columbia, Canada and Vancouver Island. The county is comprised of 172 significant islands with 359 miles of shoreline. The San Juan Islands are extremely scenic with irregular shoreline and many small harbors, rocky points and narrow channels. About 35 percent of the shoreline has rocky headlands with no beach. The remainder has beach with rocky uplands. Because of the rocky shoreline and protection in the inland waters only minor erosion is occurring. Most of the shoreline is in private ownership primarily for residential purposes. Several State Marine Parks have been developed for pleasure boaters. Two islands have been set aside as National Wildlife Refuge Areas. Shoreside development has occurred in the low upland areas. The islands are mostly undeveloped because vehicular access is by ferry boat and residential water supply systems are expensive. Commercial development has occurred primarily at Friday Harbor, the largest city in the county. The islands are very popular for pleasure cruises by boaters from the population centers of Puget Sound.

WHATCOM COUNTY

Whatcom County, bordering British Columbia, Canada is the northernmost county with shoreline in the State of Washington (see plate 3). The county has 102 miles of shoreline comprising three islands, mainland and Point Roberts. Point Roberts, the westernmost portion of the country, is not connected physically with the rest of the United States. Land access to the point is through Canada. The Point has narrow sandy beaches with privately owned uplands. Minor noncritical erosion has occurred along its southwestern shoreline.

About three-fourths of the county's mainland shoreline has narrow irregular sand and gravel beaches. Major indentations along the shore from north to south are Drayton Harbor, Birch Bay, Lummi Bay and Bellingham Bay. Forks of the Nooksack River empty into Lummi and Bellingham Bays.

Drayton Harbor has commercial development and a small-boat basin devoted to the commercial fishing industry in the Strait of Georgia. South of Drayton Harbor to Birch Bay is irregular high bank upland occupied by residences. Birch Bay State Park has been developed at the south end of the Bay. Wave damage to an existing revetment along the county road at Birch Bay has occurred due to extreme wind and wave conditions. South of Birch Bay to Lummi Bay the shoreline is relatively stable, mostly irregular with high banks. Refineries able to accommodate large tankers have been developed in this area. The Lummi Indian Reservation is located on Lummi Bay and on Bellingham Bay west of the Nooksack River. Erosion has occurred along this portion of Bellingham

Bay, causing abandonment of about 1,000 feet of county road. Relocation of the road was found to be cheaper than action to prevent erosion. Development in this area is sparse and devoted mostly to summer home use. The city of Bellingham, the largest city in the county, occupies the eastern portion of Bellingham Bay and is a port for ocean-going commerce. Industrial development and bulkhead construction have occurred along the city's waterfront. South of Bellingham to the county line the shoreline is irregular with narrow sand and gravel beaches interspersed with rocky headlands. The Burlington-Northern Railroad occupies most of this shoreline. Rock revetments have been constructed to prevent wave damage to the track. High bank uplands adjacent to the railroad have been developed for residential use. Larrabee State Park is in this reach. Lummi Island is the only island in the county devoted to residential use. The shoreline of this island is very irregular mostly with high bluffs. About half the shoreline of this island has no beach.

Federal navigation projects in the county provide for dredged waterways and a small-boat harbor at Bellingham.

SKAGIT COUNTY

The 127 miles of shoreline of Skagit County are very irregular along several islands and mainland (see plates 3 and 4). Three major bays, Samish, Padilla and Skagit Bays, are located along the shoreline.

Samish Bay is a large tideflat with largely undeveloped shoreline and upland use devoted to light agriculture. The Burlington Northern Railroad occupies the Bay's northern shoreline. Minor erosion is occurring at Samish Bay. The shoreline of Padilla Bay to the south is much the same as that along Samish Bay. Bayview State Park is located on Padilla Bay. Anacortes, the largest city in the county, is located west of Padilla Bay on Fidalgo Island. Anacortes' waterfront has been developed for commercial and industrial use. Federal navigation projects at Anacortes provide for a dredged commercial waterway and a small-boat harbor. The Swinomish Channel which separates Fidalgo Island from the mainland, is also a Federal navigation project. The southern portion of the island is occupied by the Swinomish Indian Reservation. Skagit Bay to the south is a large delta area of the Skagit River. The shoreline along the Bay is marshy tideflat. Portions of the uplands are used for agricultural purposes.

ISLAND COUNTY

Island County is located at the inland end of the Strait of Juan de Fuca near the entrance of Puget Sound (see plate 4). The county comprises two islands, Whidbey and Camano. Whidbey is one of the largest islands in the contiguous United States. The county has 194 miles of shoreline mostly undeveloped because of high bluffs. Six miles have irregular rocky headlands without beach. The rest of the

shoreline is also irregular with narrow sand and gravel beaches. Saratoga Passage separates the two islands and is a popular cruising area for Puget Sound pleasure boaters. Island County's protected shoreline has only minor erosion problems, as most of the shoreline is undeveloped. The Whidbey Island Naval Air Station occupies shoreline on Whidbey Island near Oak Harbor, the largest city in the county. There are four State parks on Whidbey Island, and one on Camano Island. Several private recreational resorts occupy shoreline in the county. The Federal Government has constructed a breakwater and mooring basin on the west side of Whidbey Island at Lake Crockett.

SNOHOMISH COUNTY

There are 43 miles of shoreline in Snohomish County extending south from Skagit Bay, Port Susan and Possession Sound to King County (see plates 4 and 5). The portion of Skagit Bay shoreline in the county is marshy and undeveloped. The Stillaguamish River empties into Skagit Bay and Port Susan. The delta area of the Stillaguamish River also consists of marshy shoreline. Uplands in this area are developed for agricultural purposes. The shoreline along the northern portion of Port Susan is irregular with wide sandy beach and high bank uplands. Summer homes have been developed along this area. The southern portion of Port Susan to the Snohomish River delta is irregular with narrow sand and gravel beach and generally high bank uplands, with the exception of Tulalip Bay which has low bank uplands. Minor noncritical erosion is occurring along the Port Susan shoreline near Tulalip Bay. The Tulalip Indian Reservation is located in this area.

The Snohomish River delta shoreline is largely marshy with some agricultural use on the lower reach of the river. The city of Everett, population 53,600, occupies uplands on the south bank of the Snohomish River. The city's waterfront has been developed for commercial and industrial purposes. A small-boat harbor is located in this commercial area. Federal projects consisting of a navigation channel and training dike have been constructed at Everett.

The Burlington-Northern Railroad occupies the shoreline from Everett south to King County. Rock revetments have been constructed to protect the railroad bed from wave damage. The highbank uplands adjacent to the railroad have been developed for residential purposes. A small-boat basin and petroleum storage area are located near the southern county line at Edmonds.

KING COUNTY

The 113 miles of King County shoreline (see plate 5) consist generally of narrow sand and gravel beach with high bank uplands. From the Snohomish County line to Shilshole Bay the shoreline is occupied by the Burlington Northern Railroad. A rock revetment has been constructed along the track to prevent wave damage. The high bank uplands

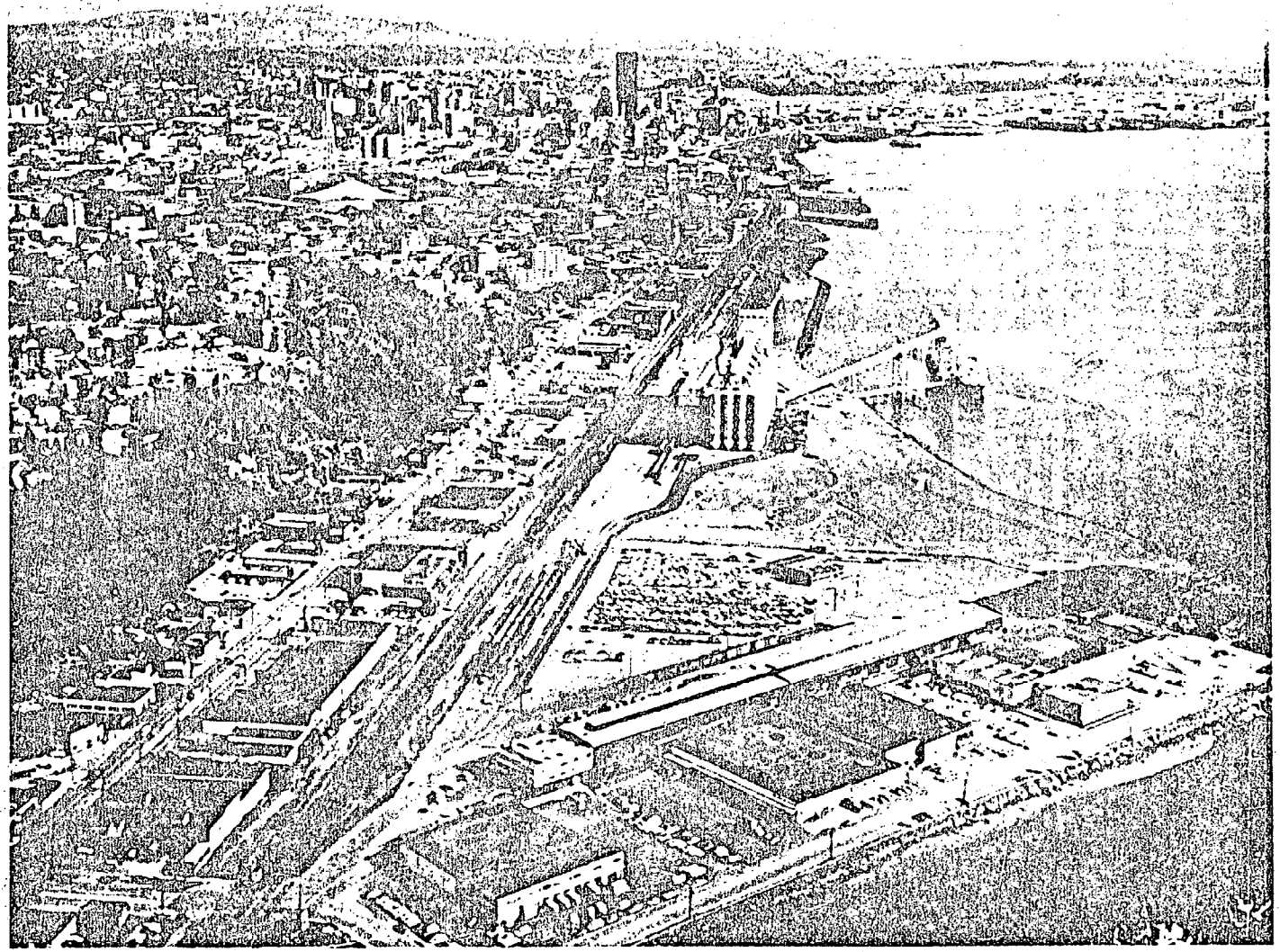


PHOTO 3. SEATTLE, WASHINGTON, WATERFRONT (Photo by Port of Seattle)

beyond are used for residences. The city of Seattle extends from the Shilshole Bay area south past Elliott Bay. Seattle is the largest city in the State with population 530,800. The Fort Lawton Military Reservation occupies most of the shoreline between Shilshole and Elliott Bays. However, portions of Fort Lawton including the shoreline have been declared surplus by the Federal Government and are proposed for development as a park. Elliott Bay is highly developed for commercial and industrial purposes (see photo 3). Its port facilities are the largest in the Pacific Northwest and the closest major port facility to Alaska and the orient. The Duwamish River empties into the southern part of Elliott Bay. A seawall has been constructed along Seattle's central waterfront.

From Elliott Bay south to the Pierce County line the shoreline is irregular with narrow sand and gravel beach adjacent to high bank uplands. Residences have been developed along the top of these bluffs.

Vashon Island southwest of Seattle comprises the remainder of King County shoreline. The island's shoreline is also irregular with narrow sand and gravel beaches adjacent to high bluffs. The island is devoted to residential and agricultural purposes.

Minor noncritical erosion is occurring at widely scattered spots along King County's shoreline. Federal navigation projects in King County consist of a small-boat harbor at Shilshole Bay, the Lake Washington Ship Canal and Locks near Shilshole Bay and waterways in the Duwamish River. Several State, county and city parks have been developed on King County's shoreline.

PIERCE COUNTY

The shoreline in Pierce County is quite irregular consisting of many bays and several islands (see plates 5 and 6). The county has 235 miles of shoreline on both the east and west sides of Puget Sound. Beginning at Commencement Bay at Tacoma (population 154,600) the shoreline is highly industrialized and is one of the major ports in Puget Sound. The shoreline south to the mouth of the Nisqually River, on the west side of the Sound and on the islands has narrow sand and gravel beach generally adjacent to high bluff. The shoreline at the Nisqually delta is quite marshy.

A critical erosion problem exists along about 0.5 mile of shoreline at Titlow Beach south of Tacoma. This bank, about 15 to 20 feet high, has been eroding for many years at the rate of one foot per year. The beach and backland is part of a city park, and the city desires to control this erosion so that recreation facilities may be developed. Erosion at this location could be prevented by a rock revetment at a cost of approximately $230,000. However, the breakwater of a small boat harbor proposed by the Port of Tacoma for the Titlow Beach area could protect the shoreline.

Pierce County's uplands adjacent to the shoreline is mostly in private ownership. There is a State park north of Commencement Bay and a large city park at the north end of the Narrows. A Federal penitentiary is on McNeill Island. The Fort Lewis Military Reservation is located north of the Nisqually River. The Burlington Northern Railroad occupies the shoreline from the north end of the Narrows to the Nisqually River. Federal navigation projects in the county consist of several waterways in Commencement Bay.

THURSTON COUNTY

The 90 miles of Thurston County shoreline comprise many long narrow inlets from the Nisqually River east past Olympia, the State Capitol and the southern end of Puget Sound and north to the Mason County line (see plate 6). The entire shoreline is irregular with narrow sand and gravel beach generally adjacent to high bluffs. Olympia has a population of 23,100. The waterfront at Olympia has been developed for commercial and industrial purposes. Most of the uplands are privately owned. The entire shoreline in the county is relatively stable. A deep-draft navigation channel and turning basin have been constructed at Olympia by the Federal Government.

MASON COUNTY

Mason County shoreline totals 174 miles along the east side of Puget Sound and the southern portion of Hood Canal (see plates 6 and 7). This part of the Puget Sound area is rural. The largest city is Shelton with a population of about 6,500. The Puget Sound shoreline in the county is irregular with narrow sand and gravel beach. Many long narrow inlets comprise this portion of the shoreline. The uplands are primarily privately owned. Shelton is a lumber-mill town with its waterfront devoted to industry and log storage areas. There are two State marine parks in this part of Puget Sound.

The lower part of Hood Canal has an irregular shoreline with narrow sand and gravel beaches. Most of the low bank waterfront has been developed for summer home use. There are three State parks on Hood Canal in Mason County: Belfair, Twanoh and Potlatch. The Skokomish Indian Reservation is at the south end of the Canal.

Much of the shoreline in the county is undeveloped, particularly along high banks where access to water is difficult. The entire shoreline is relatively stable. The Federal Government has dredged a channel from deep-water in Puget Sound to Shelton.

KITSAP COUNTY

Kitsap County occupies most of the north and central part of the Kitsap Penninsula between Puget Sound and Hood Canal and Bainbridge Island (see plates 5, 6, and 7). Bremerton, home of the Puget Sound

Naval Shipyard, is the principal city in the county. Both the Hood Canal and Puget Sound shorelines in the county are generally irregular with narrow sand and gravel beach, with the exception of the navigation facilities at the naval installations in the county and the marshy areas at the heads of narrow inlets. Most of the uplands adjacent to the shoreline are privately owned. Several State parks are located in the county. Bainbridge Island is a popular residential area for people commuting to Seattle. Much of the shoreline is undeveloped, particularly along high banks. Federal navigation projects in the county include a small boat basin at Kingston and a waterway at Port Gamble. The entire shoreline in Kitsap County is generally stable.

JEFFERSON COUNTY-INLAND SHORELINE

The Jefferson County shoreline described here includes shoreline along Hood Canal, Puget Sound and the Strait of Juan de Fuca (see plate 7). The county has 136 miles of shoreline on Puget Sound and 26 along the Strait. Beginning at the boundary with Mason County and proceeding north to Point Wilson the shoreline is generally irregular with narrow sand and gravel beaches, interspersed with a few rocky headlands along the way. Dabob Bay on Hood Canal and Port Townsend Bay near Point Wilson are major features along the shoreline. Indian and Marrowstone Islands form the southern part of Port Townsend Bay. This portion of the shoreline is relatively stable. Indian Island is a naval installation. Most of the other shoreline is privately owned. Pleasant Harbor, a State marine park, and Dosewallips, a State park, are near the south end of Dabob Bay. Fort Flagler, Fort Worden and Old Fort Townsend State Parks are on Port Townsend Bay. Federal navigation projects include a small-boat basin at Port Townsend and a waterway and jetties between Oak Bay and Port Townsend Bay.

The 26 miles of Jefferson County shoreline on the Strait of Juan de Fuca are irregular with narrow sand and gravel beach adjacent to high bank uplands. A major indentation along the Strait is Port Discovery. The shoreline is relatively stable and undeveloped.

CLALLUM COUNTY

There are 118 miles of shoreline in Clallum County along the Strait of Juan de Fuca between Port Discovery and Cape Flattery (see plates 7, 8, and 9). This shoreline is exposed to ocean swells.

The shoreline along the Strait of Juan de Fuca west of Port Discovery to Angeles Point is irregular with narrow sand and gravel beaches and includes two natural sand spits, both of which were formed by littoral movement of sand material eroding from adjacent banks and cliffs. Dungeness Spit, a National wildlife refuge, provides protection for Dungeness Bay, a shallow estuary important for its shellfish production and waterfowl habitat. Ediz Hook protects the city

and harbor of Port Angeles from ocean swells and wave action from the Strait. Port Angeles, a deep harbor, supports a city of approximately 16,400 population. Sequim Bay is a major feature of the shoreline between Port Discovery and Dungeness Bay.

Waves from northwesterly and westerly storms occurring during high tides have occasionally washed over the narrow portion of Ediz Hook, damaging a road and utilities, depositing debris, and sometimes breaching the Hook at one or more places (see photo 4). Comparison of condition surveys during the period 1883 to 1970 reveals that erosion has a southward trend in the narrow part or western half of the spit. The comparison also shows a progressive elongation of the spit eastward about 280 feet. In recent years, the increased severity and frequency of wave attack, combined with a reduction in source of beach-feed material, is threatening to breach the Hook in several places. Continued erosion would destroy the spit, forcing relocation of the Coast Guard base at its eastern extremity and eliminate the natural protection to Port Angeles Harbor, leaving port facilities and a Federally constructed boat basin vulnerable to severe wave attack. The city of Port Angeles and industries located on Ediz Hook have expended considerable funds in an effort to arrest the erosion (see photo 5).

Erosion control measures for about 1.5 miles of shoreline on Ediz Hook could involve artificial beach nourishment and construction of a rock revetment. Costs for these measures are estimated at $5,000,000 with $30,000 (1970 prices) expended for annual nourishment.

The shoreline from Angeles Point to Cape Flattery is typically narrow beach backed up by steep high bluffs with many outcrops of rock. There are two important small bays along this reach of shoreline. Clallum Bay is a small sport-fishing boat harbor. Neah Bay provides a harbor for an Indian village, Coast Guard station and a large sport-fishing fleet. The Federal Government has constructed a breakwater at Neah Bay to provide a protected harbor for the fishing fleet.

Most of the shoreline along the Strait of Juan de Fuca is privately owned and undeveloped. The Makah Indian Reservation is located at Neah Bay and Cape Flattery. Minor noncritical erosion is occurring along the shoreline west of Kydaka Point.

There are 36 miles of Pacific Ocean shoreline in the county (see plates 9 and 10), about 22 miles of which have narrow sandy beaches with steeply sloping uplands. The remainder of the shoreline is near vertical rocky headlands. Cape Alava is a prominent headland in this reach. The entire area is isolated and heavily forested, with little or no development.

PHOTO 4. EDIZ HOOK, WASHINGTON (JUNE 1970). EROSION CAUSED BY STORM WAVES

PHOTO 5. EDIZ HOOK, WASHINGTON (JUNE 1970). REVETMENT PLACED BY CITY OF PORT ANGELES. BEACH IS USED FOR BEACHCOMBING, SUNBATHING, AND PICNICKING.

The Ozette Indian Reservation is located at Cape Alava. The Olympic National Park occupies the uplands from Cape Alava south to the county line except for a small area at La Push near the mouth of the Quillayute River. The Quillayute Indian Reservation is located here.

Critical erosion has occurred along 0.4 mile of a sand spit which protects a Federal navigation channel and the small-boat basin at La Push. This sand spit is nourished almost annually by utilizing material from the maintenance dredging required for the navigation projects. The cost for dredging the channel and moorage area and nourishing the sand spit is about $90,000 annually (1970 prices). A large sport fishing fleet and a U.S. Coast Guard Station are located at La Push.

JEFFERSON COUNTY-OCEAN SHORELINE

Jefferson County has 32 miles of shoreline on the Pacific Ocean (see plate 10). From the Clallum County line south to the Hoh River the shoreline is irregular with narrow sandy beaches interspersed with rocky headlands. From the Hoh River south to the Grays Harbor County line there are straight sandy beaches.

The Olympic National Park occupies most of the shoreline in the county except for the Hoh Indian Reservation at the mouth of the Hoh River and the Quinault Indian Reservation at the southern county line. U.S. Highway 101 parallels the shoreline between the Hoh and Queets Rivers.

GRAYS HARBOR COUNTY

Grays Harbor County has a total of 146 miles of shoreline consisting of 57 miles on the Pacific Ocean and 89 miles along the Grays Harbor estuary (see plates 10, 11 and 12).

The ocean shoreline from the Queets River to Point Brown at the entrance to Grays Harbor consists primarily of flat straight sandy beaches with dunes and grassland abutted by low bank gently sloping upland. Interspersed at frequent intervals are reaches of steeply sloping high bank terrain with narrow beaches. The Quinault Indian Reservation occupies the shoreline from the Queets River to the Moclips River. The shoreline from the Moclips River to Point Brown has many summer residences and is extensively used for recreational purposes. Ocean City State Park is located in this area (see photo 6).

The shoreline north of Grays Harbor is generally stable. However, noncritical erosion is occurring in the vicinity of the Moclips River and at Copalis Beach. The State Highway Department has used riprap to protect the highways in the area from damage.

PHOTO 6. OCEAN CITY STATE PARK, WASHINGTON. RECREATIONAL USE (CLAM-DIGGING) OF PACIFIC OCEAN SHORELINE. (Photo by Washington State Parks and Recreation Commission)

Grays Harbor is a estuary of the Pacific Ocean, at the mouth of the Chehalis River, about 45 miles north of the mouth of the Columbia River and 110 miles south of the entrance to the Strait of Juan de Fuca. The harbor broadens gradually from the river channel at Aberdeen to a broad, pear-shaped shallow estuary encompassing North and South Bays. Most of the shoreline has wide tideflats, except for marshy areas near the mouths of some rivers. The natural harbor entrance, 2 miles wide, is enclosed by two narrow sandy spits, Point Brown on the north and Point Chehalis on the south. Point Chehalis encloses a small bay utilized by the town of Westport, an important recreational area, and Westhaven Cove, a Federally constructed small-boat basin for commercial and sport-fishing fleets. Point Brown is at the southern tip of a penninsula separating North Bay from the ocean. An extensive privately owned recreational and real estate development known as Ocean Shores is located on the peninsula. Two convergent Federally constructed rock jetties extend seaward from Points Brown and Chehalis, constricting the harbor entrance to 6,500 feet. A Federal navigation channel has been constructed from the Grays Harbor entrance to Aberdeen.

Grays Harbor estuary is important for its shellfish production although intensive industrial shoreline development has occurred at the cities of Aberdeen and Hoquiam. Twin Harbors State Park is located just south of Westport. Considerable private development has occurred around the estuary, particularly at Ocean Shores.

Wave action has caused noncritical erosion on the shoreline adjacent to State Highway 109 west of Hoquiam. The State Highway Department has successfully protected the highway with a rock revetment. Critical erosion of 0.6 mile along Point Chehalis is occurring in spite of a Federal project consisting of a rock revetment and rock and timber-pile groins constructed to curb it. Preliminary costs for an revetment and groin system are estimated at $1,000,000 (1970 prices).

The remainder of Grays Harbor County shoreline from Westport south to Pacific County is straight with wide sandy beaches backed up by dunes. The beach area is used for recreational purposes while the uplands have been developed for residential and resort use. State Highway 105 generally parallels this shoreline.

The Corps of Engineers is currently investigating improvement to the navigation facilities in Grays Harbor. A model of the estuary will provide data on the complex interaction of the ocean, river and estuary. Improvements being considered involve a revised entrance jetty system, erosion control at Point Chehalis, and a suitable navigation channel.

PACIFIC COUNTY

Pacific County shoreline totals 185 miles: 30 miles on the Pacific Ocean, 129 miles in Willapa Bay and 26 miles along the Columbia River (see plate 12).

The shoreline from the Grays Harbor County line to the entrance to Willapa Bay is straight with wide sandy beaches backed up by dunes. The beach area is used for recreational purposes while the uplands have been developed for residential and resort use. State Highway 105 generally parallels the shoreline.

Willapa Bay is a large estuary of the Pacific Ocean, about 28 miles north of the mouth of the Columbia River and 17 miles south of the entrance to Grays Harbor. The entrance, about 5 miles wide, is between Cape Shoalwater on the north and North Beach Peninsula on the south.

Cape Shoalwater borders Willapa Bay on the north of the estuary entrance. The Cape consists of sand dunes adjacent to the beach, wooded sand ridges up to 40 feet high to the east and relatively low wooded areas beyond.

Willapa Bay has two arms, the south arm extending about 19 miles from the entrance, and the east arm extending about 12 miles east to the mouth of the Willapa River. The water surface of Willapa Bay varies from 110 square miles at high tide to about 60 square miles at low tide. Vast shoals and tideflats exposed at the lower tidal stages account for the large difference in surface area. About half the shoreline in the estuary is marshy. The area is rich in natural resources, including fish and shellfish and has a large recreational potential.

Willapa Bay estuary is noted for commercial oyster production. Shoreline development is limited. Timber and related industries are located at Raymond. Deep-draft navigation facilities including a Federally constructed channel have been built to accommodate these industries. Developments along portions of the estuary's shoreline comprise residential and summer home use. A portion of Cape Shoalwater and the southern part of the Bay, including Long Island, consists of National wildlife refuge areas. The Federal Government has constructed small-boat harbors at the southeastern tip of Toke Point. Bush Pacific Pioneer State Park is located near the mouth of the Palix River.

North Beach Peninsula is a low sandy spit extending south from the entrance to Willapa Bay to Cape Disappointment at the mouth of the Columbia River. The Peninsula is about 1-1/2 miles wide and separates the south arm of Willapa Bay from the Pacific Ocean. Timber and other vegetation cover the peninsula, except for about 4 miles at the north end (Leadbetter Point). The ocean beach which is straight, about one-half mile wide, composed of sand and backed up by sand dunes, is

heavily used for recreation purposes. The uplands are used for summer residences and resorts. A portion of Leadbetter Point is planned for future development as a State park. The point is also part of the Willapa National Wildlife Refuge.

A complex interaction of natural forces, such as the tidal currents, littoral drift, and the wind waves and swells of southwest ocean storms, is critically eroding about 3 miles of the beach and undermining the upland areas at Cape Shoalwater. The shoreline has moved about 11,500 feet northward since 1887. The current rate of erosion averages about 150 feet per year and the erosion will continue if uncontrolled (see photo 7). The erosion is undermining an existing low bank and debris held against the bank by waves creates a potential hazard to visitors. The erosion has destroyed valuable recreational beaches, public highways and roads, a school, many residences, and other public and private buildings, and forced the relocation of a Coast Guard Lighthouse Station (see photo 8). It is also threatening other public and private lands and buildings, including the relocated Coast Guard Lighthouse Station and State Highway 105, the direct highway link between the urban and recreational areas to the east and south with those to the north. Eroded material at Cape Shoalwater contributes to the shoaling of the navigation channel across the harbor's outer bar. Efforts by local interests to control the erosion by a series of groins constructed of timber-piles and automobile bodies (see photo 9) have been unsuccessful as the groins have completely disappeared. About 1 mile of the eastern end of the eroded shoreline is owned by the Federal Government as a wildlife refuge. The rest is privately owned.

The Corps of Engineers is conducting preliminary studies of navigation improvements at Willapa Bay, including erosion control at Cape Shoalwater, to determine the feasibility of detailed investigations of the problems and their solutions. A model of the Willapa Bay estuary should be part of any detailed investigation because of complex interactions between the ocean and estuary.

Stabilizing 3 miles of eroding shoreline at Cape Shoalwater without regard to provision for a navigation channel might require a concrete mattress for bank protection or structures for channel diversion, or a combination of both. There is no assurance that these structural measures would be successful without a hydraulic model investigation of the Willapa Bay estuary. This type of protection is estimated to cost between $30 and $100 million (1970 prices). A nonstructural alternative of buying land susceptible to erosion and relocating existing structures and residents is estimated to cost about $4 million (1970 prices).

Toke Point is a narrow peninsula extending about 13,000 feet in a southeasterly direction from the north shore of Willapa Bay, about 5 miles east of the estuary entrance from the ocean. Approximately 1.3 miles of the southern end of the Point have eroded an average of 12

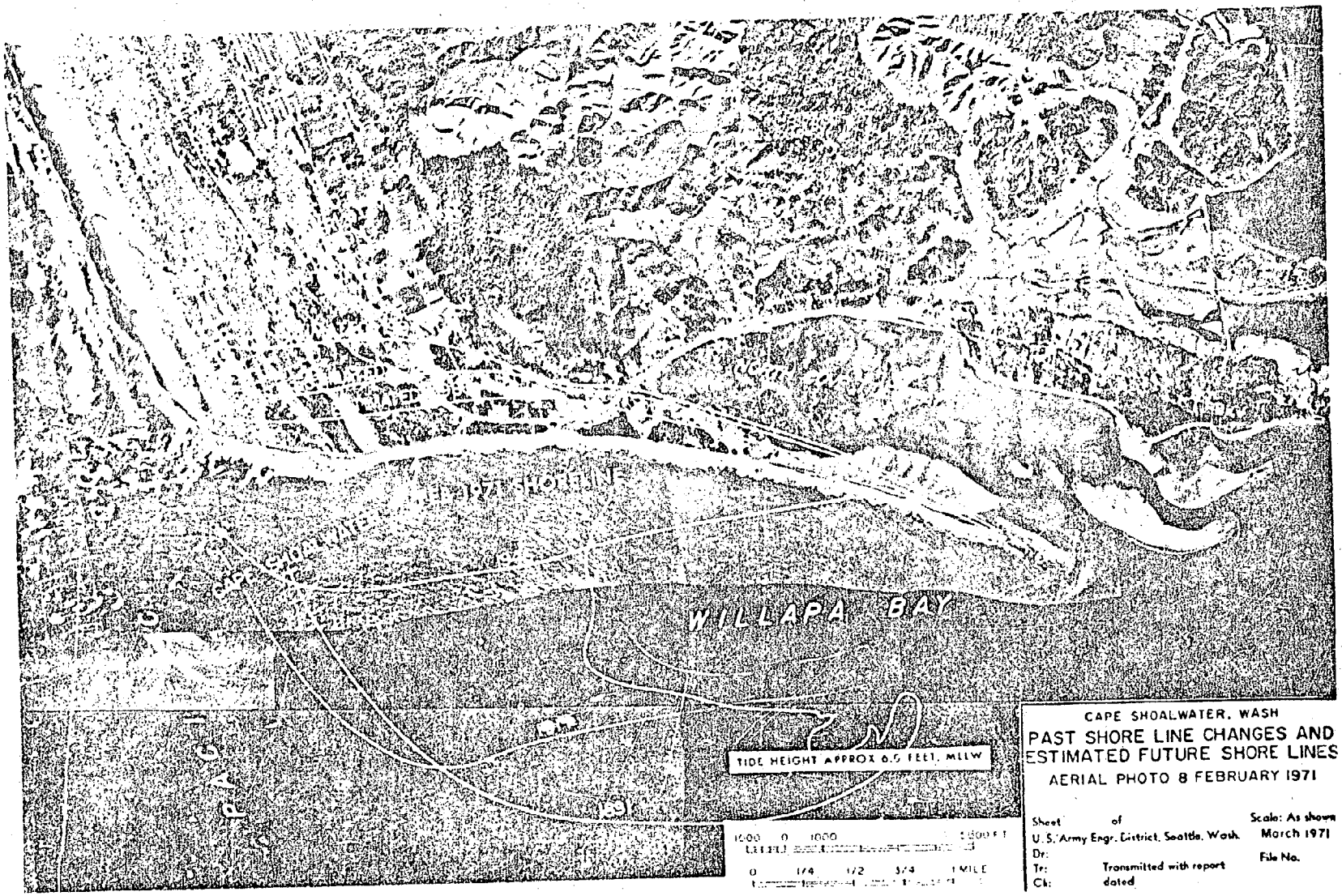

WILLAPA BAY
TIDE HEIGHT APPROX 6.5 FEET, MLLW
1000 0 1000 2000 FEET
0 1/4 1/2 3/4 1 MILE
CAPE SHOALWATER, WASH
PAST SHORE LINE CHANGES AND ESTIMATED FUTURE SHORE LINES
AERIAL PHOTO 8 FEBRUARY 1971
Sheet of
U.S. Army Engr. District, Seattle, Wash.
Scale: As shown
March 1971
Dr:
Tr:
Ck:
Transmitted with report dated
File No.

PHOTO 7.

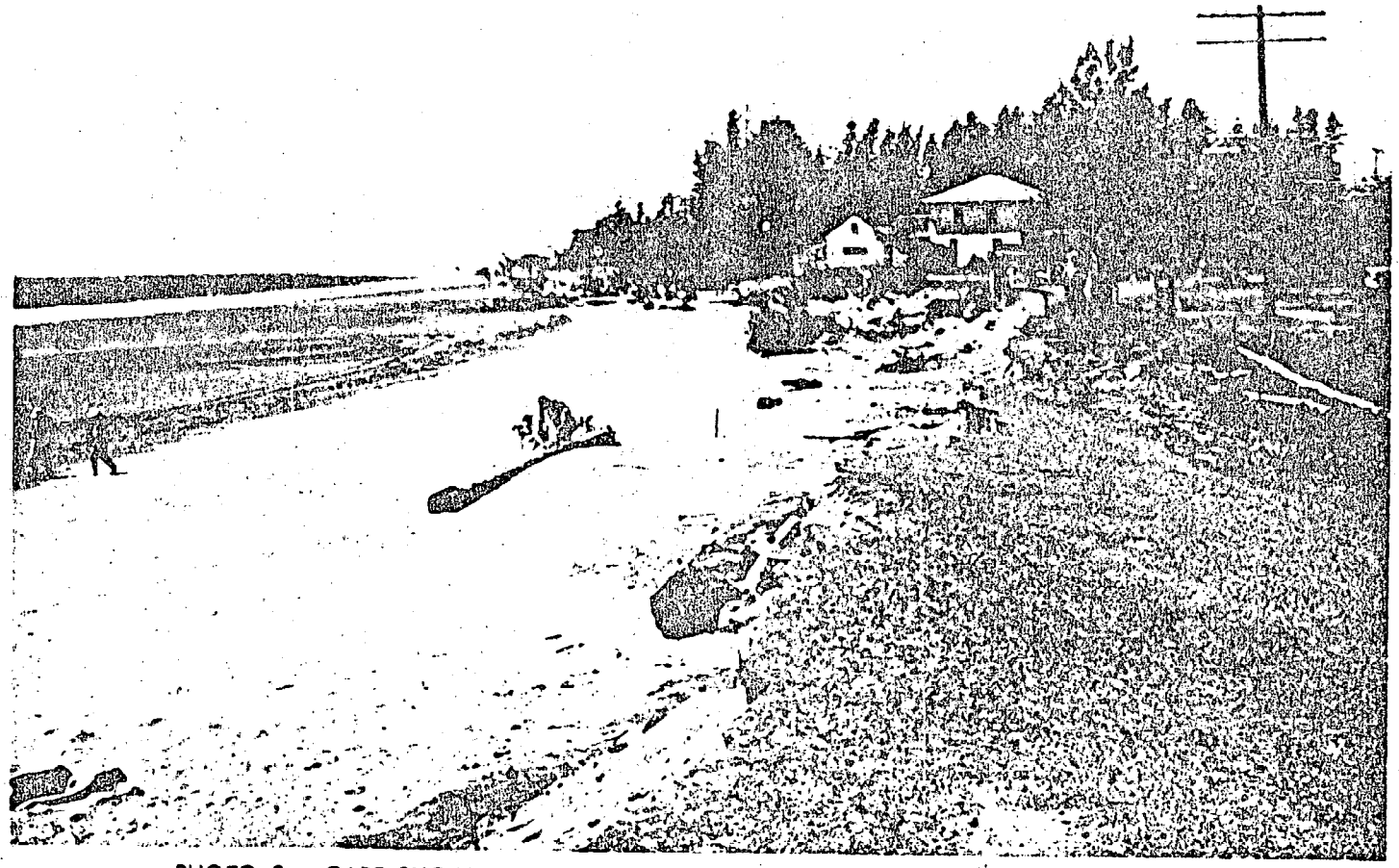


PHOTO 8. CAPE SHOALWATER, WASHINGTON (JUNE 1970). EROSION HAS CUT A ROADWAY SHOWN ON THE RIGHT FOREGROUND AND THREATENS A HOUSE AND GARAGE. THE HOUSE AND GARAGE WERE DESTROYED IN DECEMBER 1970. THE BEACH IS USED FOR SUNBATHING AND BEACHCOMBING.

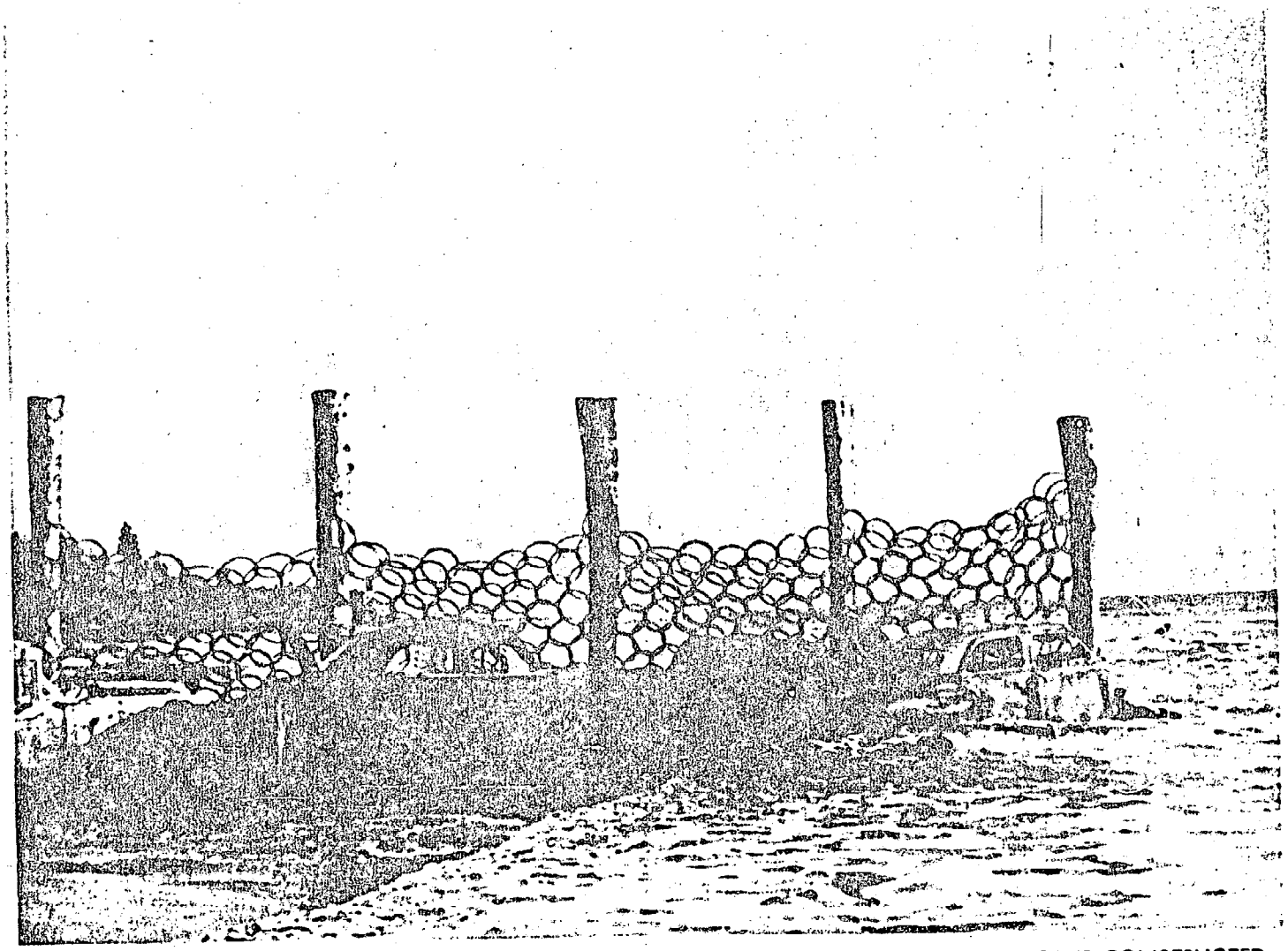


PHOTO 9. CAPE SHOALWATER, WASHINGTON (January 1966). ONE OF THREE GROINS CONSTRUCTED BY LOCAL RESIDENTS, WITH ANTISUBMARINE NETS AND OLD AUTOMOBILES. THESE GROINS WERE UNSUCCESSFUL IN CONTROLLING EROSION. (Photo courtesy of Eugene B. Congdon.)

feet per year for the past 50 years. Toke Point has a shrimp, oyster, and crab processing plant; a small-boat basin and Coast Guard facilities; many summer homes; and a population of about 700. Economic activity and population have been decreasing; the decline is primarily attributed to the beach erosion. Erosion has resulted in the loss of 17 city blocks of developed property, has destroyed a beach area along the southern shore, and is threatening a county highway. Storm waves threaten to breach the lower part of the Point and form a tidal slough which would be gradually enlarged by each subsequent storm. Breaching would result in the loss of a small-boat basin, Coast Guard facilities, 7 platted city blocks, and approximately 10 acres of land. The area north of Toke Point would also be exposed to wave action by breaching of the Point. This area includes 800 acres of fertile farmland, and a new section of State Highway 105 which skirts the shoreline.

A system of rock groins and a rock revetment has been considered for protecting Toke Point from further erosion. The estimated cost for this type of protection is $2,300,000 (1970 prices).

About 2,000 feet of beach on the Willapa Bay side of the North Beach Peninsula are eroding. Investigation indicates that the erosion is noncritical and on private property.

About 3,000 feet of Rhodesia Beach, privately owned upland near the mouth of the Palix River in Willapa Bay, has suffered noncritical erosion in recent years. Rock revetment and timber-pile breakwaters constructed by local interests have been largely successful in halting the erosion.

The remainder of Pacific County shoreline lies within the Columbia River estuary. This shoreline is characterized by forested bluffs with occasional deltas formed at the mouths of tributary streams. Rocky headlands exist along portions of the shoreline. The uplands are mostly undeveloped except for the Ilwaco and Chinook areas which are devoted mostly to fishing activities. Fort Canby State Park is located near Cape Disappointment and Fort Columbia State Park is located near Chinook.

Federal navigation projects include a jetty system at the mouth of the Columbia River, a deep-draft entrance channel to the river and channels and small-boat basins at Ilwaco and Chinook.

WAHKIAKUM COUNTY

Wahkiakum County has 8 miles of shoreline between the Pacific County line and Harrington Point (see plate 12). Harrington Point is the upstream limit of Washington's shoreline considered in this inventory report.

The shoreline has narrow beach adjacent to high bluffs except for the delta area formed by the Deep and Grays River. Most of the uplands are undeveloped. State Highways 4 and 403 generally parallel the shoreline. Federal navigation projects have been constructed at Deep River and Grays River.

21. COST SUMMARY OF CONCEPTUAL PLANS FOR CRITICAL EROSION AREAS

Table 6 gives a cost summary by county of the conceptual plans for controlling critical erosion areas in Washington.

TABLE 6

COST SUMMARY OF CONCEPTUAL PLANS FOR SUITABLE PROTECTION - 1970

WASHINGTON

County (critical erosion area)	Suitable Protection	Length (miles)	First Cost	Annual Beach Nourishment
Pierce				
Titlow Beach	Rock revetment	0.5	$230,000	
Clallum				
Ediz Hook	Rock revetment & beach nourishment	1.5	5,000,000	$30,000
La Push	Beach nourishment	0.5	-	90,000
Grays Harbor				
Point Chehalis	Rock revetment & pile	0.6	1,000,000	
Pacific				
Cape Shoalwater	Property acquisition 1/	3.0	4,000,000	
Toke Point	Rock revetment and groins	1.3	2,300,000	
TOTAL		7.3	$12,530,000	$120,000

1/Structural alternative would cost in excess of $30 million.

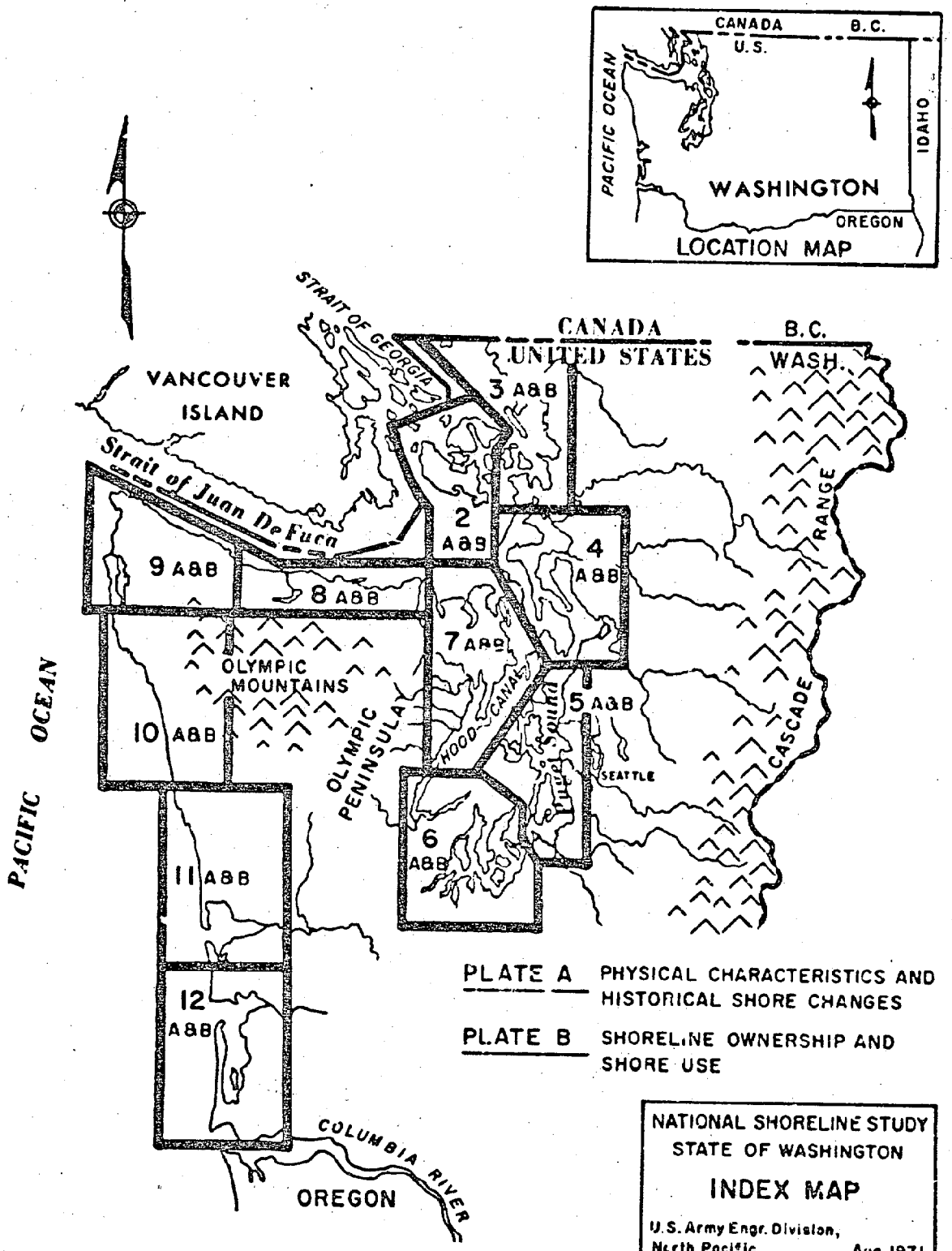


PLATE A PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

PLATE B SHORELINE OWNERSHIP AND SHORE USE

NATIONAL SHORELINE STUDY
STATE OF WASHINGTON

INDEX MAP

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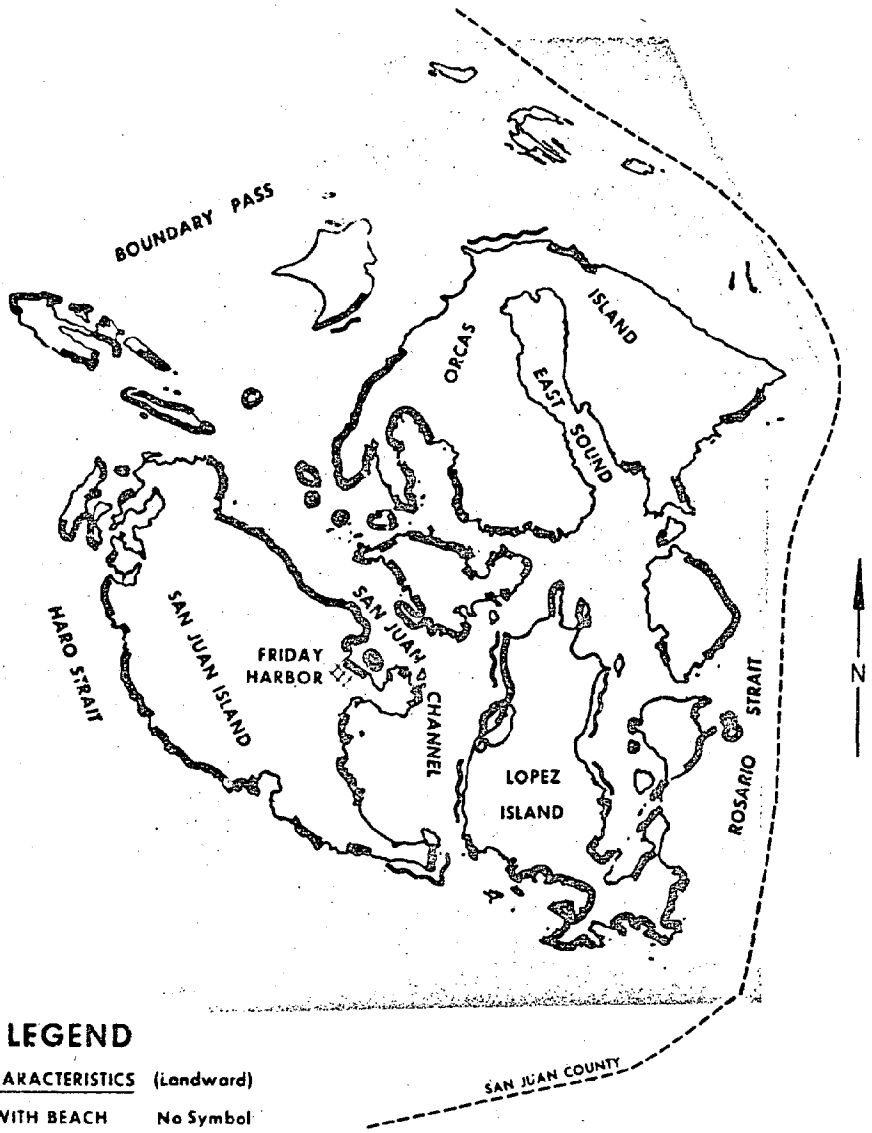
PLATE 1



LEGEND

PHYSICAL CHARACTERISTICS (Landward)

SHORELINE WITH BEACH	No Symbol
SHORELINE WITHOUT BEACH	▬▬▬

HISTORICAL SHORE CHANGES (Seaward)

CRITICAL EROSION	▪▪▪▪▪▪▪
NON-CRITICAL EROSION	~~~~
NO EROSION	No Symbol

SCALE IN MILES

5 0 1 2 3 4 5

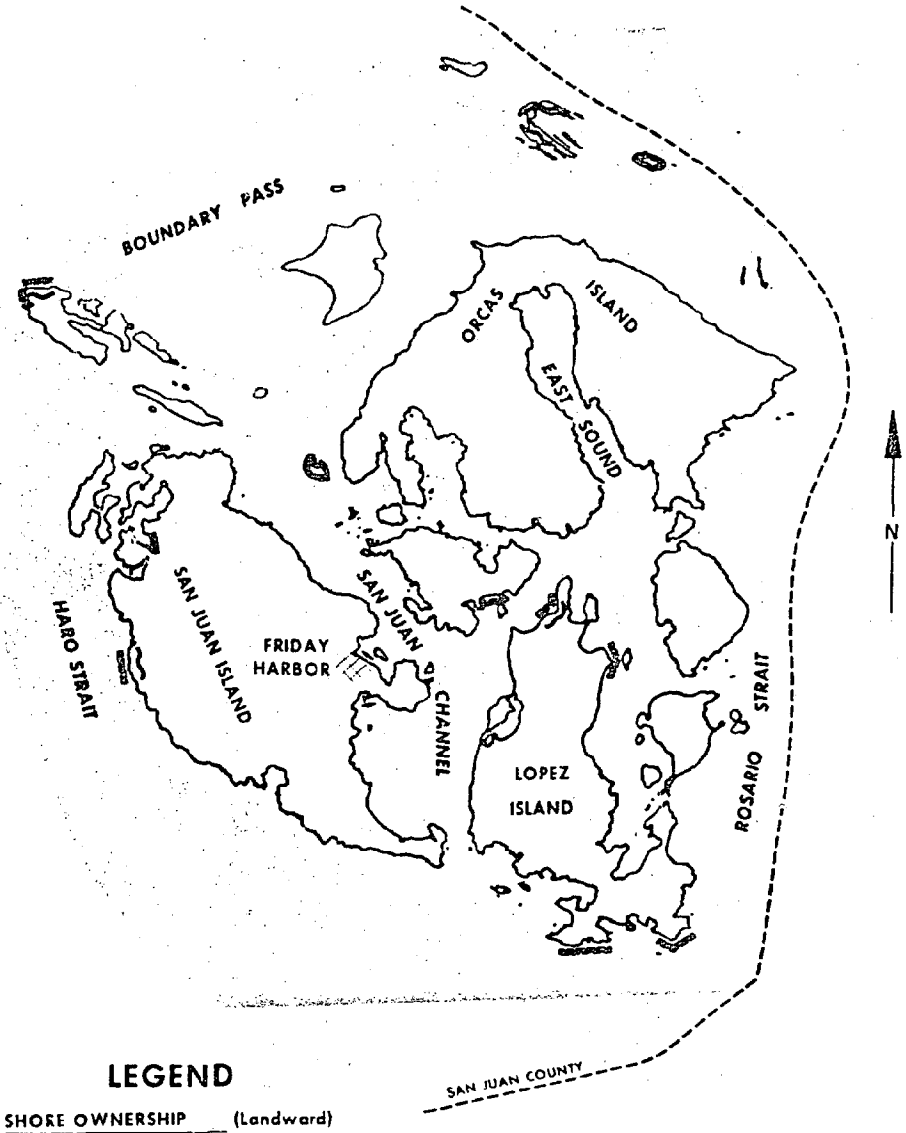
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON

PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. D-IC-5-1

PLATE 2A



LEGEND

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PUBLIC (NON-FEDERAL)	
PRIVATE	No Symbol
SHORE USE	(Seaward)
RECREATIONAL-PUBLIC	
RECREATIONAL-PRIVATE	
NON-RECREATIONAL DEVELOPMENT	
UNDEVELOPED	No Symbol

SCALE IN MILES

5 0 1 2 3 4 5

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STATE OF WASHINGTON

SHORE OWNERSHIP AND SHORE USE

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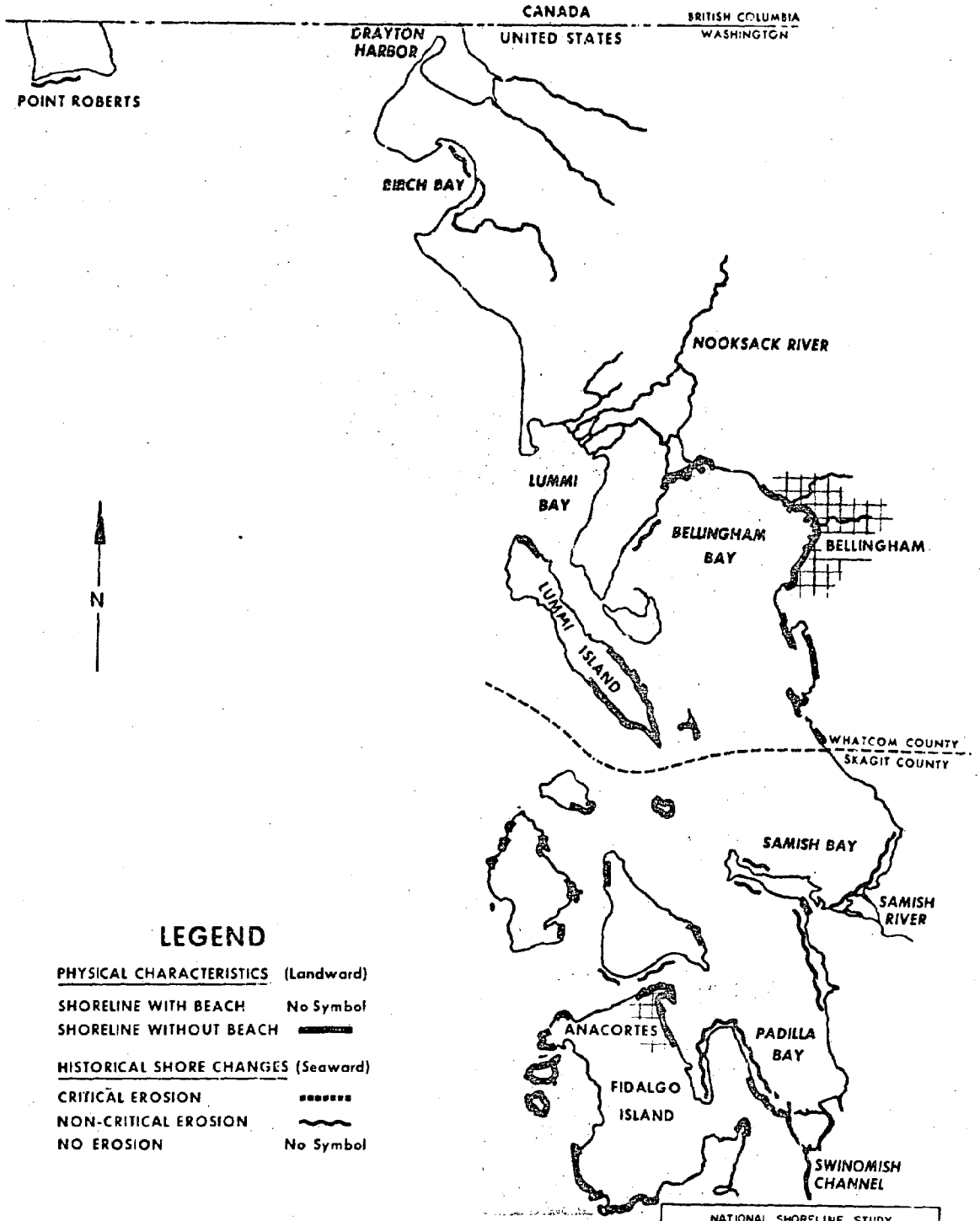
PLATE 2B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BRITISH COLUMBIA
UNITED STATES
WASHINGTON
POINT ROBERTS
DRAYTON HARBOR
BIRCH BAY
NOOKSACK RIVER
LUMMI BAY
BELLINGHAM BAY
BELLINGHAM
LUMMI ISLAND
N
WHATCOM COUNTY
SKAGIT COUNTY
SAMISH BAY
SAMISH RIVER
ANACORTES
PADILLA BAY
FIDALGO ISLAND
SWINOMISH CHANNEL
LEGEND
PHYSICAL CHARACTERISTICS (Landward)
SHORELINE WITH BEACH No Symbol
SHORELINE WITHOUT BEACH
HISTORICAL SHORE CHANGES (Seaward)
CRITICAL EROSION
NON-CRITICAL EROSION
NO EROSION No Symbol
SCALE IN MILES
5 0 1 2 3 4 5
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON
PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES
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PLATE 3A

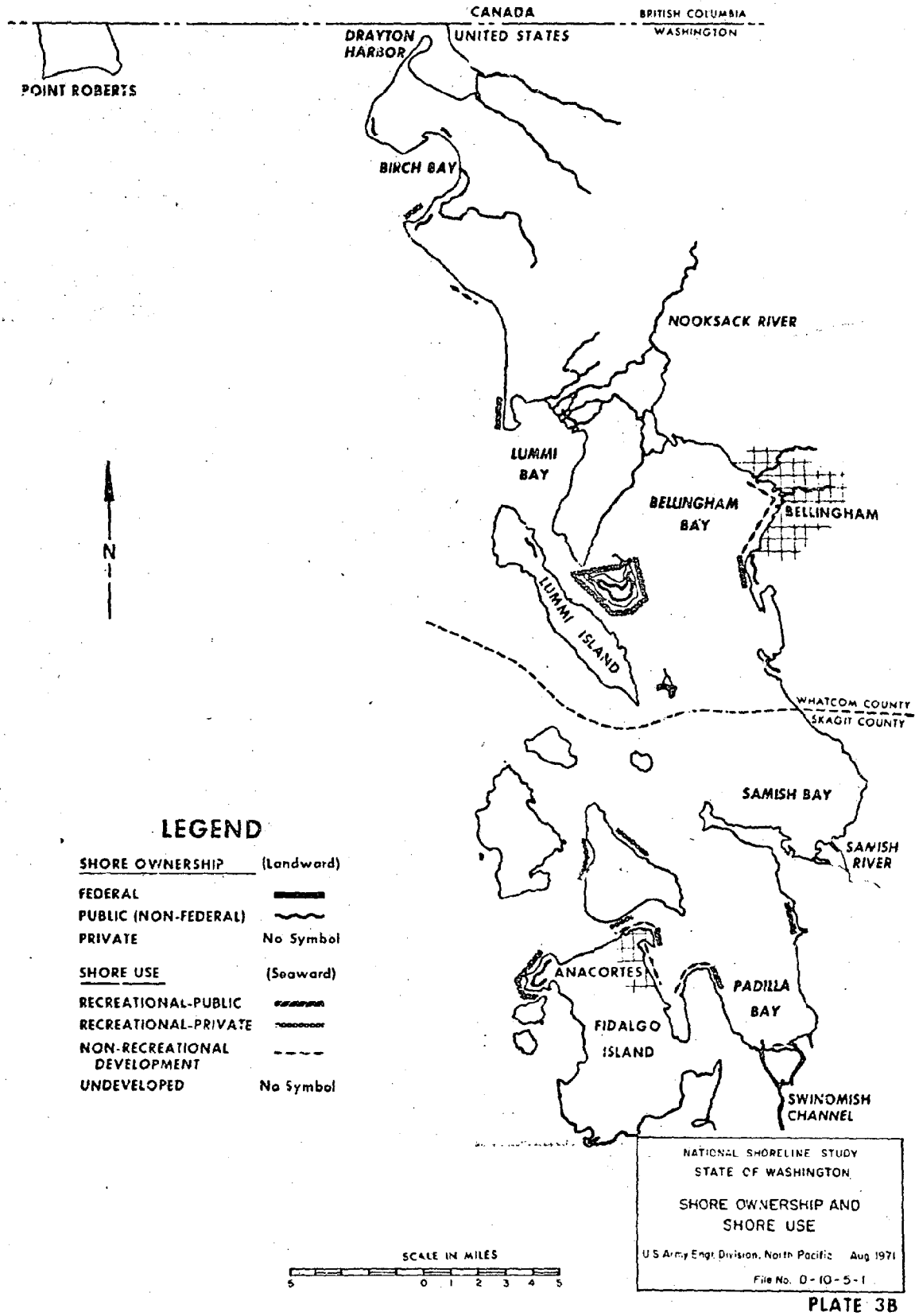
CANADA
BRITISH COLUMBIA
WASHINGTON
UNITED STATES
DRAYTON HARBOR
POINT ROBERTS
BIRCH BAY
NOOKSACK RIVER
LUMMI BAY
BELLINGHAM BAY
BELLINGHAM
LUMMI ISLAND
WHATCOM COUNTY
SKAGIT COUNTY
SAMISH BAY
SAMISH RIVER
ANACORTES
PADILLA BAY
FIDALGO ISLAND
SWINOMISH CHANNEL
N
LEGEND
SHORE OWNERSHIP (Landward)
FEDERAL
PUBLIC (NON-FEDERAL)
PRIVATE No Symbol
SHORE USE (Seaward)
RECREATIONAL-PUBLIC
RECREATIONAL-PRIVATE
NON-RECREATIONAL DEVELOPMENT
UNDEVELOPED No Symbol
SCALE IN MILES
5 0 1 2 3 4 5
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON
SHORE OWNERSHIP AND SHORE USE
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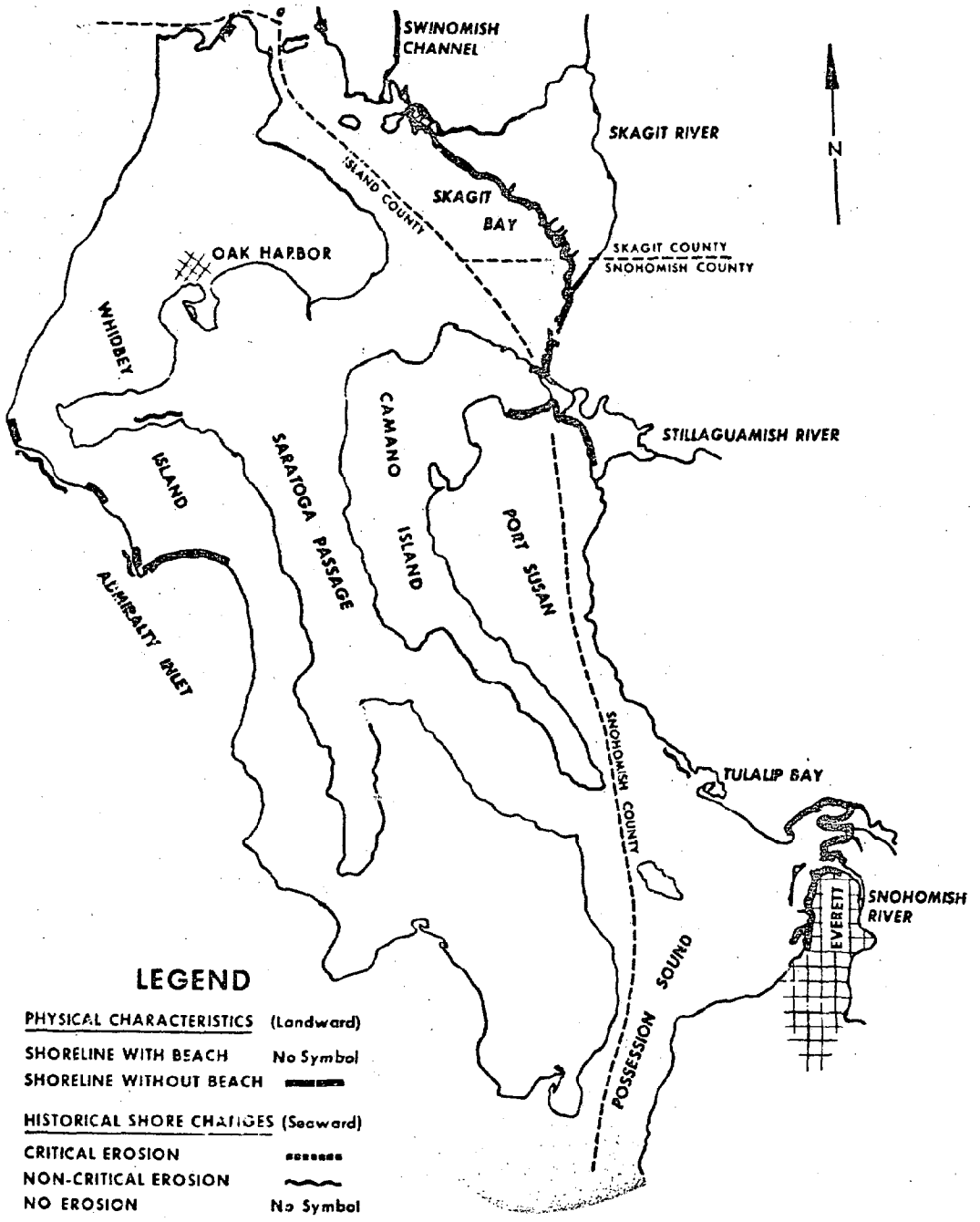
PLATE 3B



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PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

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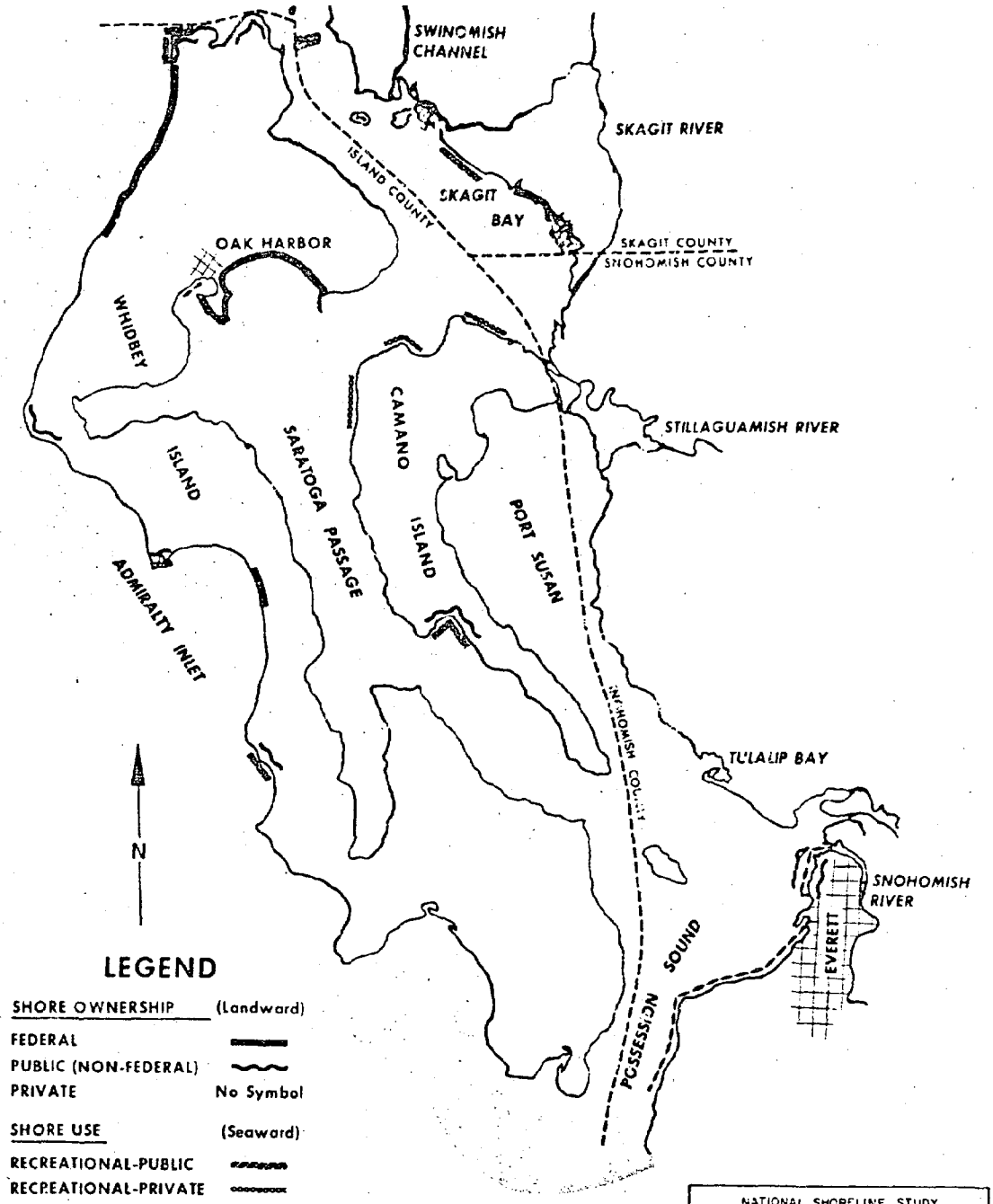
PLATE 4A



LEGEND

SHORE OWNERSHIP	(Landward)
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PUBLIC (NON-FEDERAL)	
PRIVATE	No Symbol
SHORE USE	**(Seaward)**
RECREATIONAL-PUBLIC	
RECREATIONAL-PRIVATE	
NON-RECREATIONAL DEVELOPMENT	
UNDEVELOPED	No Symbol

SCALE IN MILES

5 0 1 2 3 4 5

NATIONAL SHORELINE STUDY
STATE OF WASHINGTON

SHORE OWNERSHIP AND SHORE USE

U.S. Army Engr. Division, North Pacific Aug 1971

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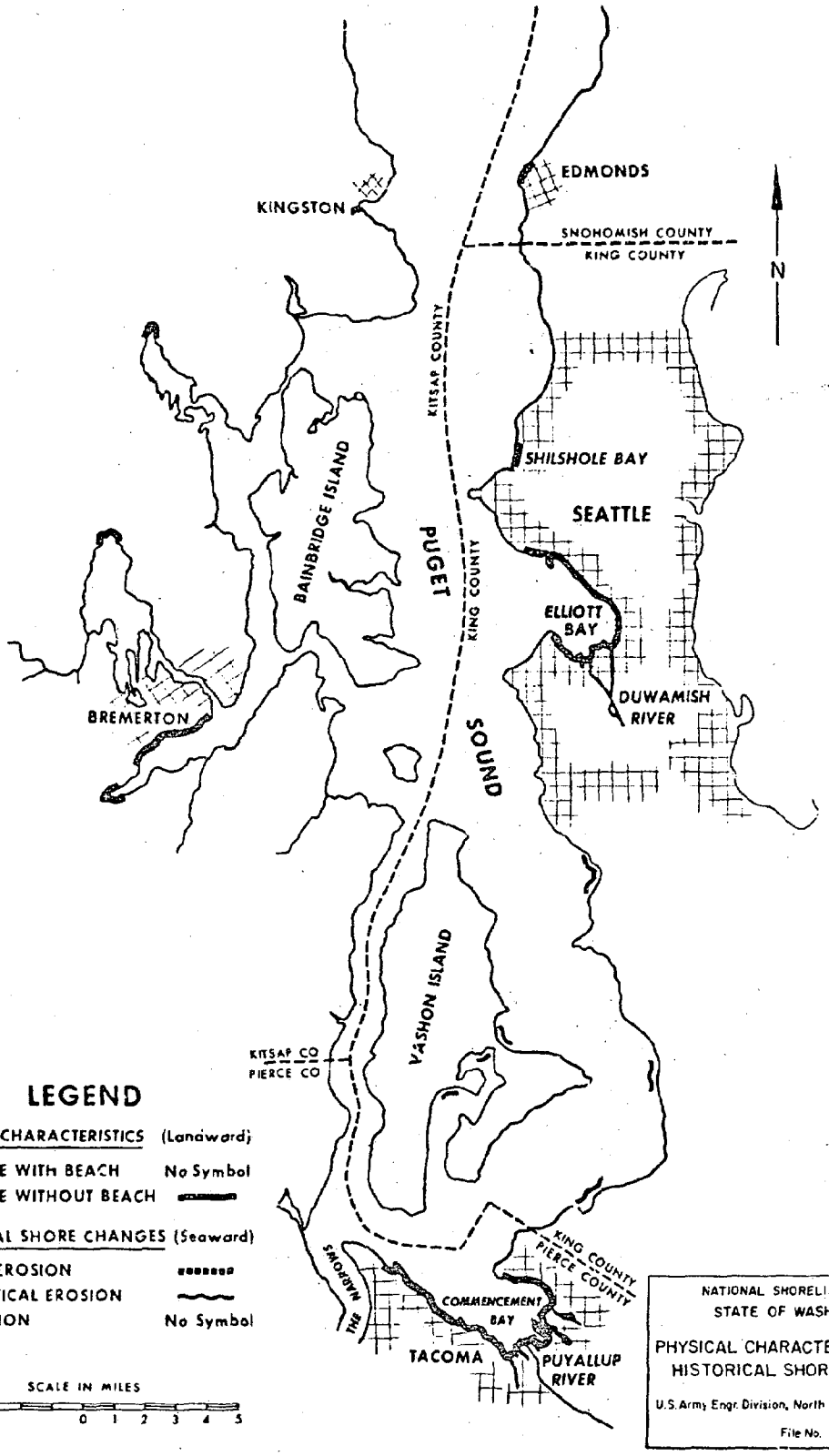
PLATE 4B



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STATE OF WASHINGTON

PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

U.S. Army Engr. Division, North Pacific Aug. 1971

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PLATE 5A

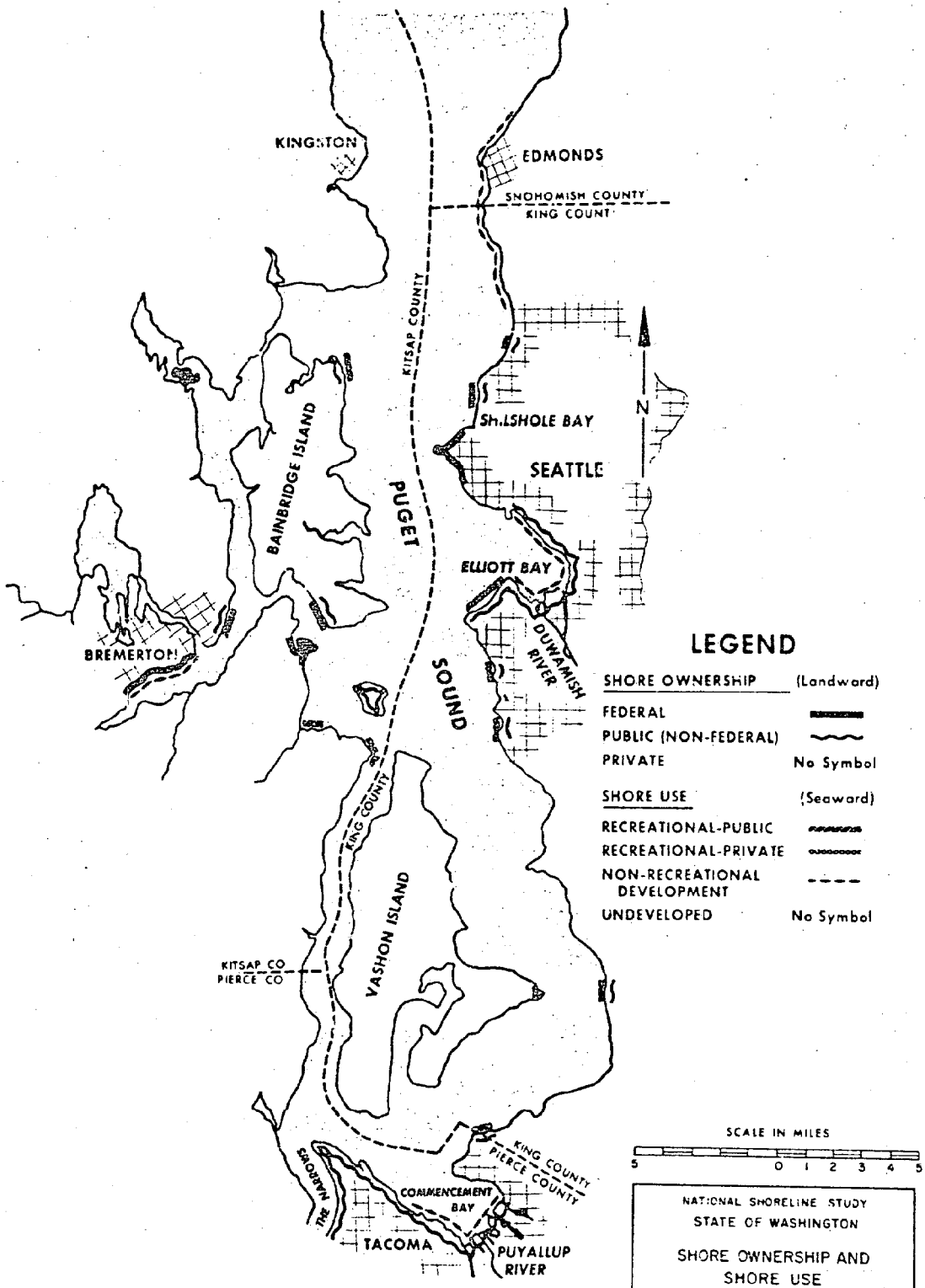
KINGSTON
EDMONDS
SNOHOMISH COUNTY
KING COUNTY
KITSAP COUNTY
BAINBRIDGE ISLAND
PUGET
SOUND
SHILSHOLE BAY
SEATTLE
N
ELLIOTT BAY
DUWAMISH RIVER
BREMERTON
KING COUNTY
VASHON ISLAND
KITSAP CO
PIERCE CO
KING COUNTY
PIERCE COUNTY
COMMENCEMENT BAY
NARROWS
TACOMA
PUYALLUP RIVER
LEGEND
SHORE OWNERSHIP (Landward)
FEDERAL
PUBLIC (NON-FEDERAL)
PRIVATE
No Symbol
SHORE USE (Seaward)
RECREATIONAL-PUBLIC
RECREATIONAL-PRIVATE
NON-RECREATIONAL DEVELOPMENT
UNDEVELOPED
No Symbol
SCALE IN MILES
5 0 1 2 3 4 5
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON
SHORE OWNERSHIP AND SHORE USE
U.S. Army Engr. Division, North Pacific Aug. 1971
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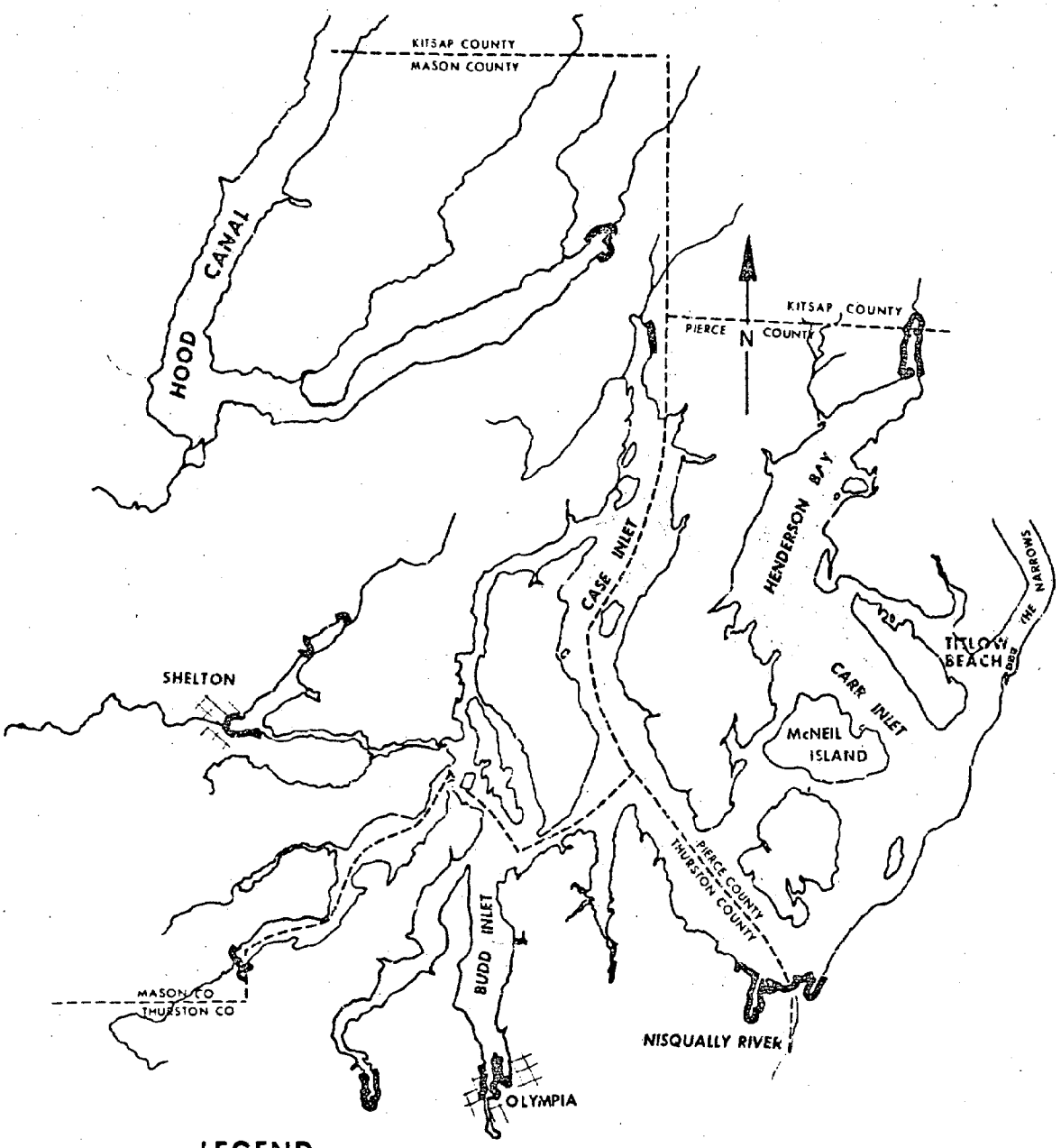
PLATE 5B



LEGEND

PHYSICAL CHARACTERISTICS (Landward)

SHORELINE WITH BEACH — No Symbol

SHORELINE WITHOUT BEACH

HISTORICAL SHORE CHANGES (Seaward)

CRITICAL EROSION

NON-CRITICAL EROSION

NO EROSION — No Symbol

SCALE IN MILES

5 0 1 2 3 4 5

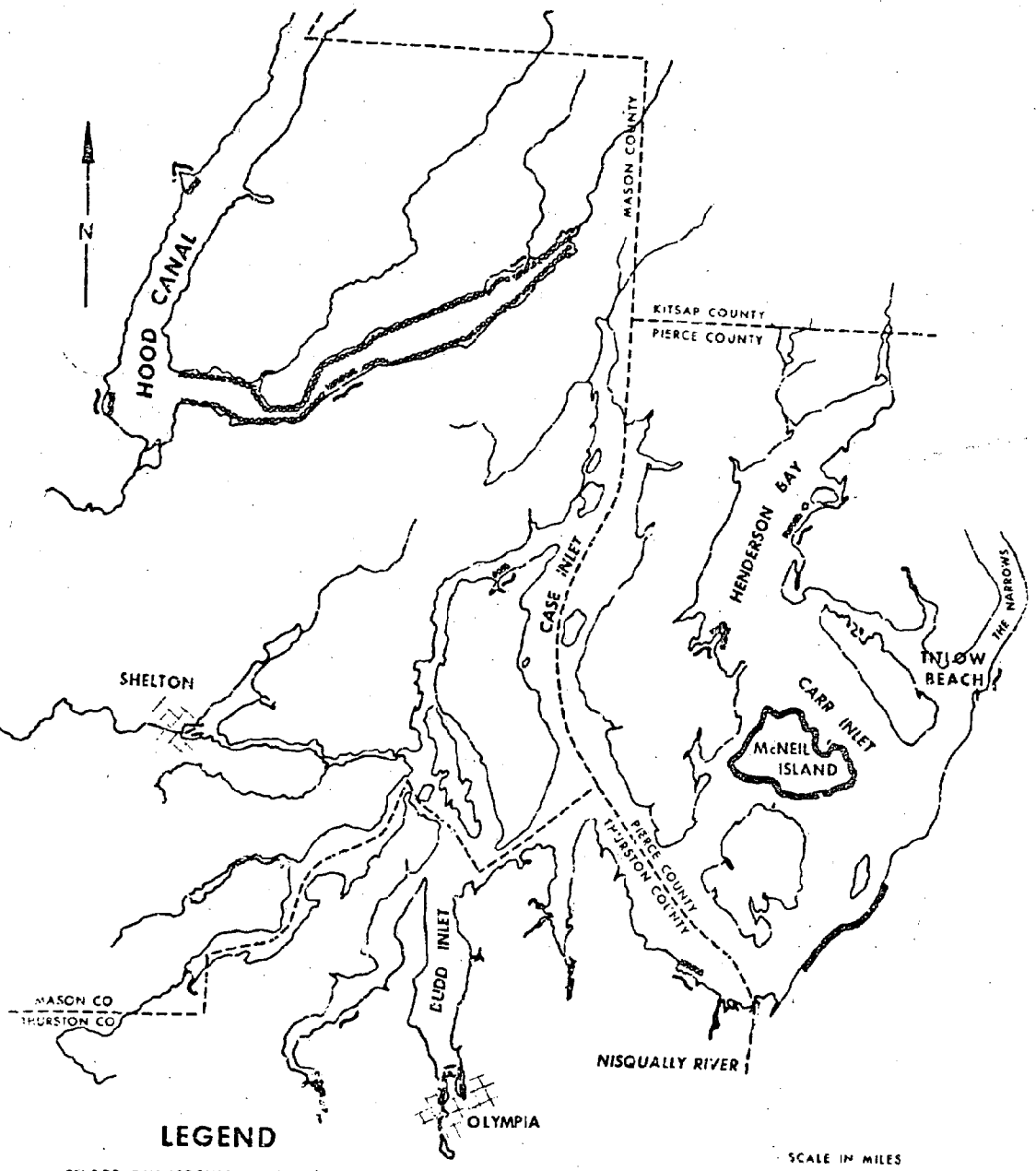
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON

PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. D-10-5-1

PLATE 6A



LEGEND

SHORE OWNERSHIP	(Landward)
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PUBLIC (NON-FEDERAL)	
PRIVATE	No Symbol
SHORE USE	**(Seaward)**
RECREATIONAL-PUBLIC	
RECREATIONAL-PRIVATE	
NON-RECREATIONAL DEVELOPMENT	
UNDEVELOPED	No Symbol

SCALE IN MILES

5 0 1 2 3 4 5

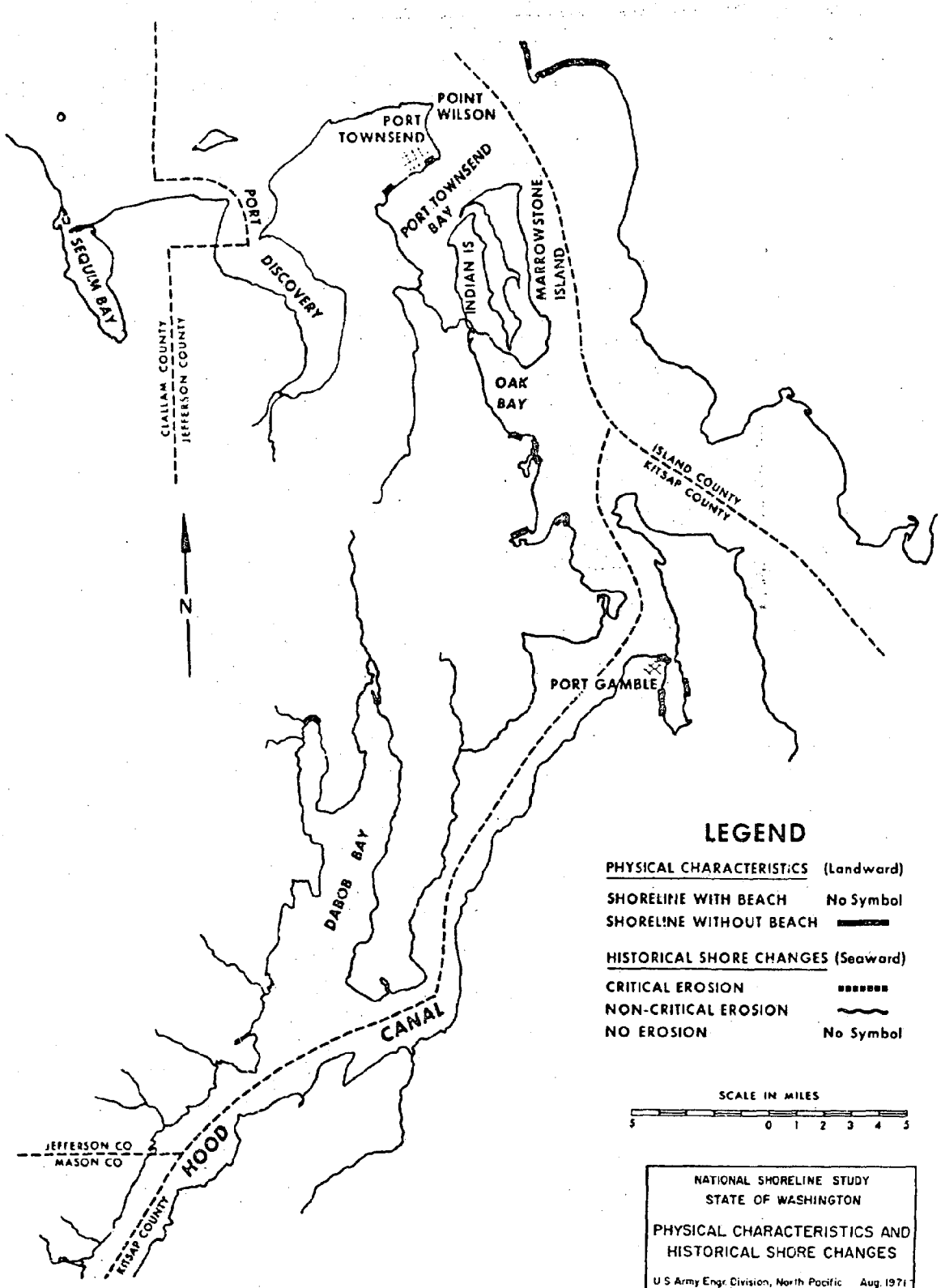
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON

SHORE OWNERSHIP AND SHORE USE

U.S. Army Engr Division, North Pacific Aug. 1971

File No. 9-10-5-1

PLATE 6B



LEGEND

PHYSICAL CHARACTERISTICS (Landward)

SHORELINE WITH BEACH — No Symbol

SHORELINE WITHOUT BEACH

HISTORICAL SHORE CHANGES (Seaward)

CRITICAL EROSION

NON-CRITICAL EROSION

NO EROSION — No Symbol

SCALE IN MILES

5 0 1 2 3 4 5

NATIONAL SHORELINE STUDY
STATE OF WASHINGTON

PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

U S Army Engr. Division, North Pacific Aug. 1971

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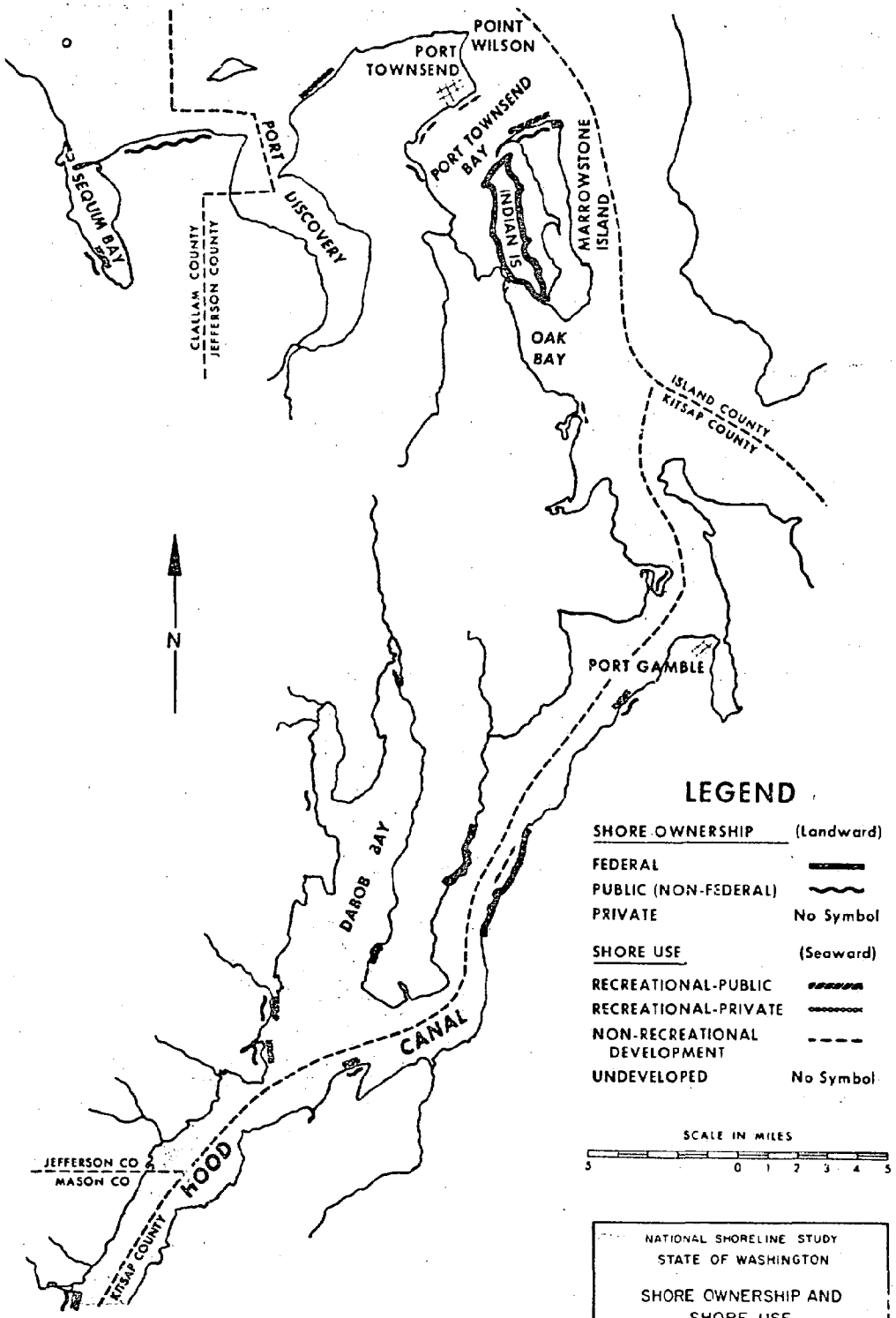
PLATE 7A


POINT WILSON
PORT TOWNSEND
PORT TOWNSEND BAY
INDIAN IS
MARROWSTONE ISLAND
PORT DISCOVERY
SEQUIM BAY
CLALLAM COUNTY
JEFFERSON COUNTY
OAK BAY
ISLAND COUNTY
KITSAP COUNTY
N
PORT GAMBLE
DABOB BAY
HOOD CANAL
JEFFERSON CO
MASON CO
KITSAP COUNTY
LEGEND
SHORE OWNERSHIP (Landward)
FEDERAL
PUBLIC (NON-FEDERAL)
PRIVATE No Symbol
SHORE USE (Seaward)
RECREATIONAL-PUBLIC
RECREATIONAL-PRIVATE
NON-RECREATIONAL DEVELOPMENT
UNDEVELOPED No Symbol
SCALE IN MILES
5 0 1 2 3 4 5
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON
SHORE OWNERSHIP AND SHORE USE
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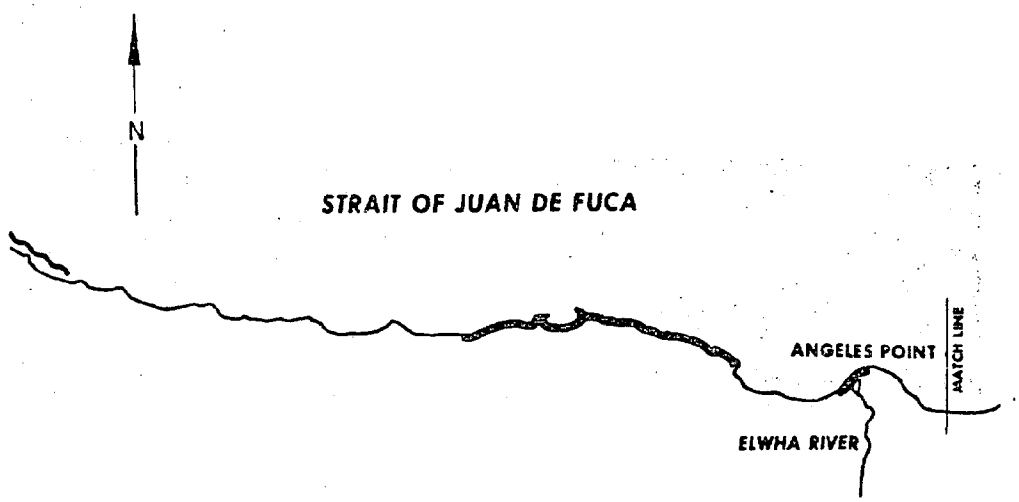
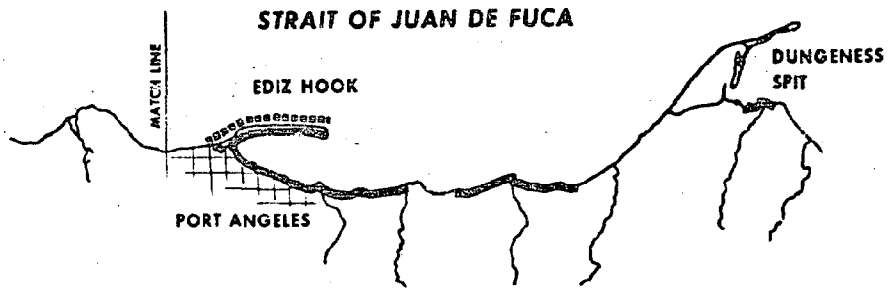
File No. D-10-5-1

PLATE 7B





LEGEND

PHYSICAL CHARACTERISTICS (Landward)

SHORELINE WITH BEACH — No Symbol

SHORELINE WITHOUT BEACH

HISTORICAL SHORE CHANGES (Seaward)

CRITICAL EROSION

NON-CRITICAL EROSION

NO EROSION — No Symbol

SCALE IN MILES

5 0 1 2 3 4 5

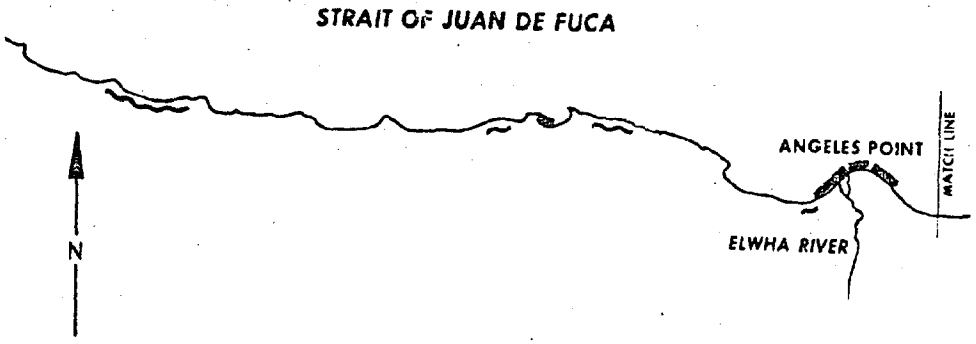
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON

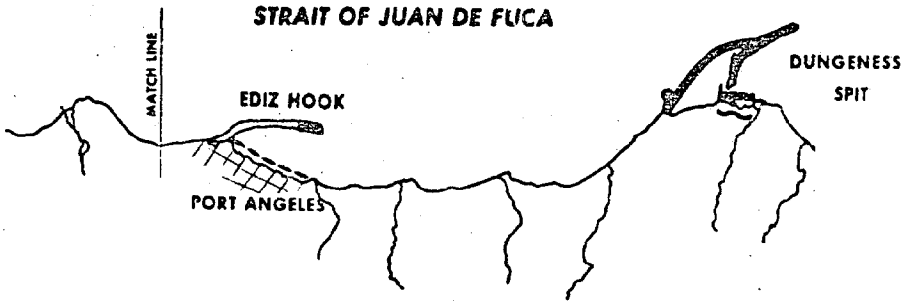
PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. D-10-5-1

PLATE 8A





LEGEND

SHORE OWNERSHIP	(Landward)	SHORE USE	(Seaward)
FEDERAL	▬▬	RECREATIONAL-PUBLIC	▬▬
PUBLIC (NON-FEDERAL)	~~~	RECREATIONAL-PRIVATE	▬▬
PRIVATE	No Symbol	NON-RECREATIONAL DEVELOPMENT	- - - -
		UNDEVELOPED	No Symbol

SCALE IN MILES

5 0 1 2 3 4 5

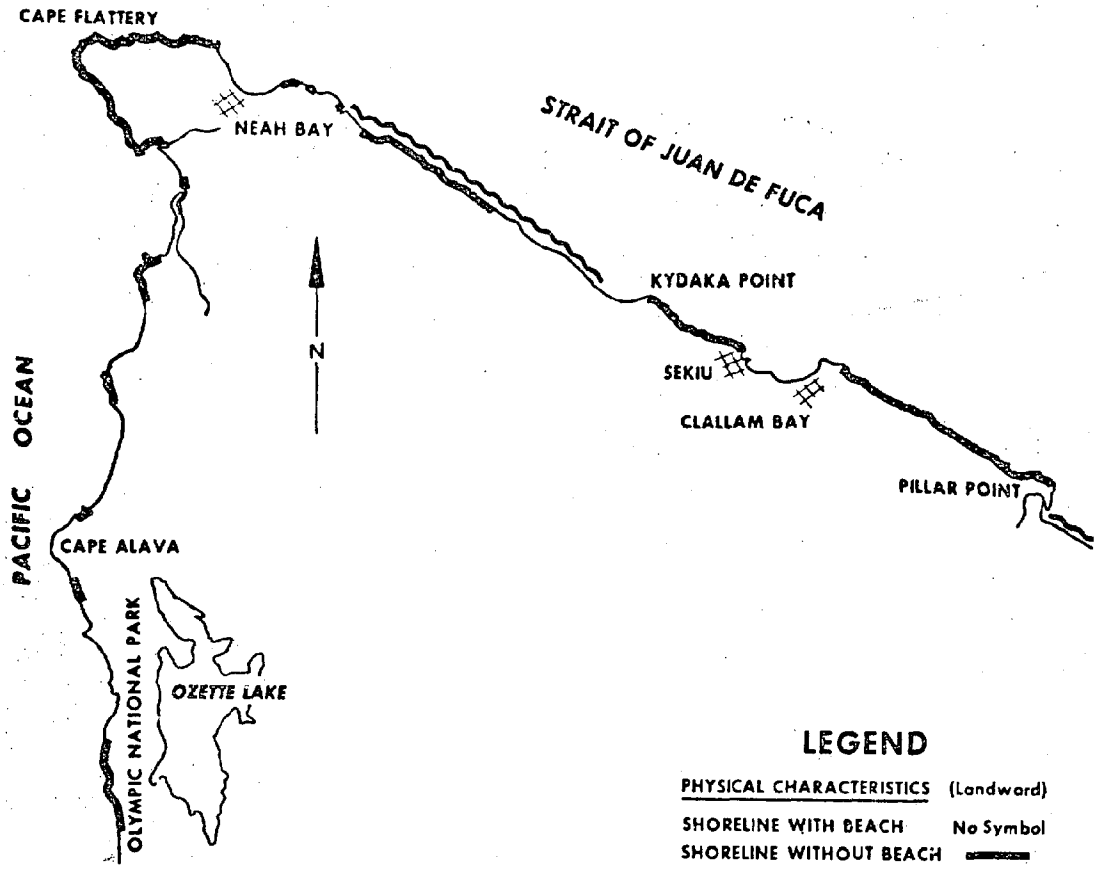
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON

SHORE OWNERSHIP AND SHORE USE

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. D-10-5-1

PLATE 8B



LEGEND

PHYSICAL CHARACTERISTICS	(Landward)
SHORELINE WITH BEACH	No Symbol
SHORELINE WITHOUT BEACH	
HISTORICAL SHORE CHANGES	(Seaward)
CRITICAL EROSION	
NON-CRITICAL EROSION	
NO EROSION	No Symbol

SCALE IN MILES

5 0 1 2 3 4 5

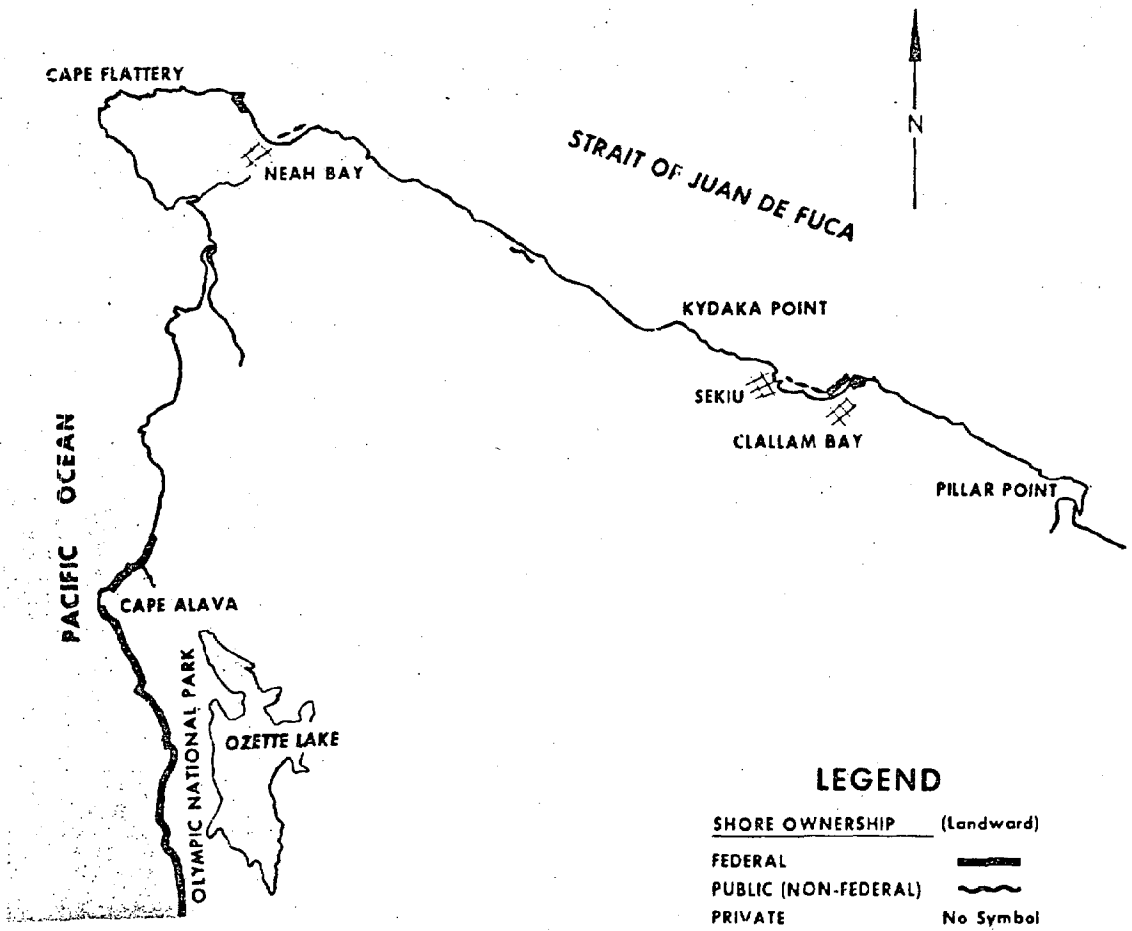
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON

PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. D-10-5-1

PLATE 9A



LEGEND

SHORE OWNERSHIP	(Landward)
FEDERAL	
PUBLIC (NON-FEDERAL)	
PRIVATE	No Symbol
SHORE USE	**(Seaward)**
RECREATIONAL-PUBLIC	
RECREATIONAL-PRIVATE	
NON-RECREATIONAL DEVELOPMENT	
UNDEVELOPED	No Symbol

SCALE IN MILES

5 0 1 2 3 4 5

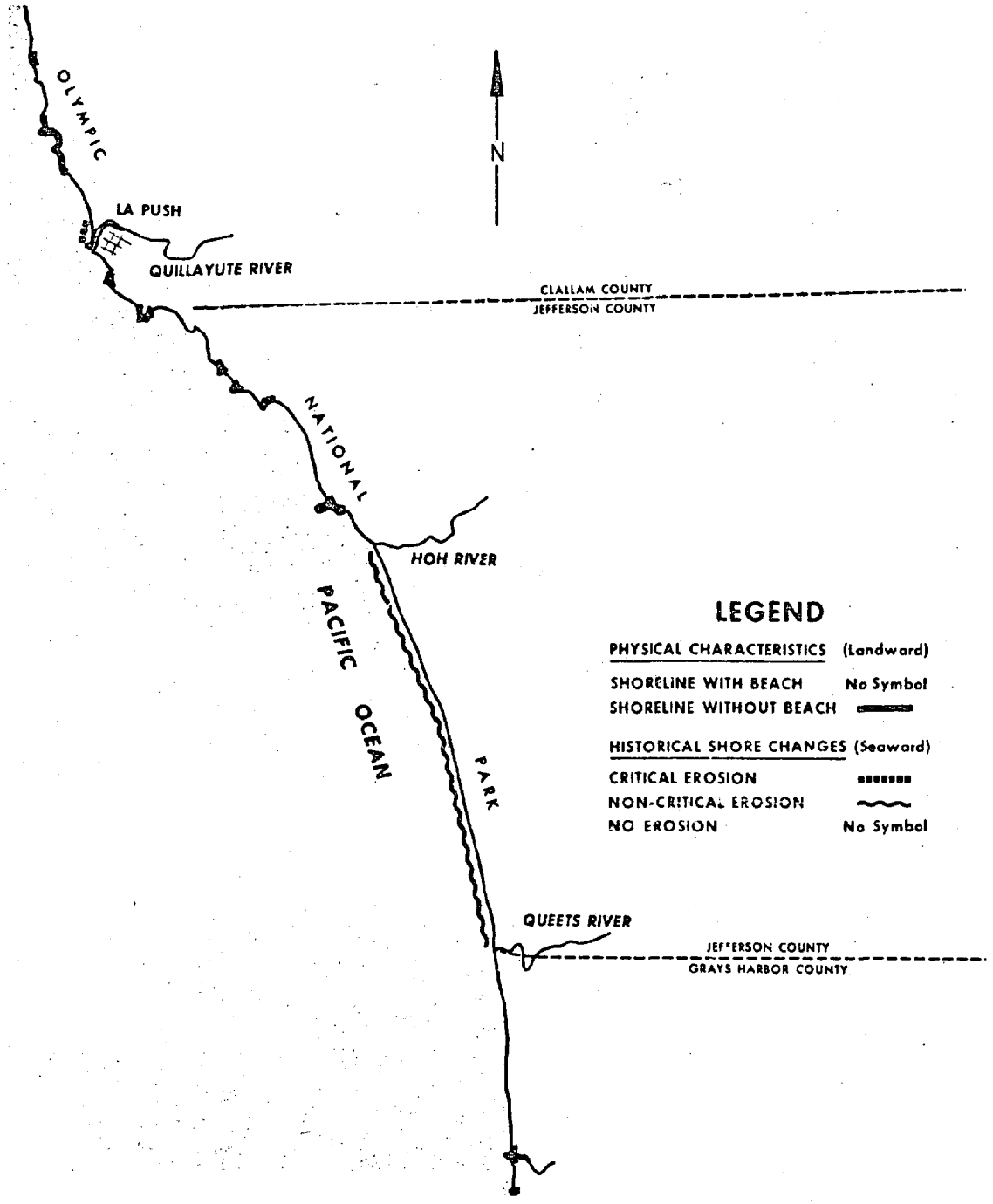
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON

SHORE OWNERSHIP AND SHORE USE

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. D-10-5-1

PLATE 9B



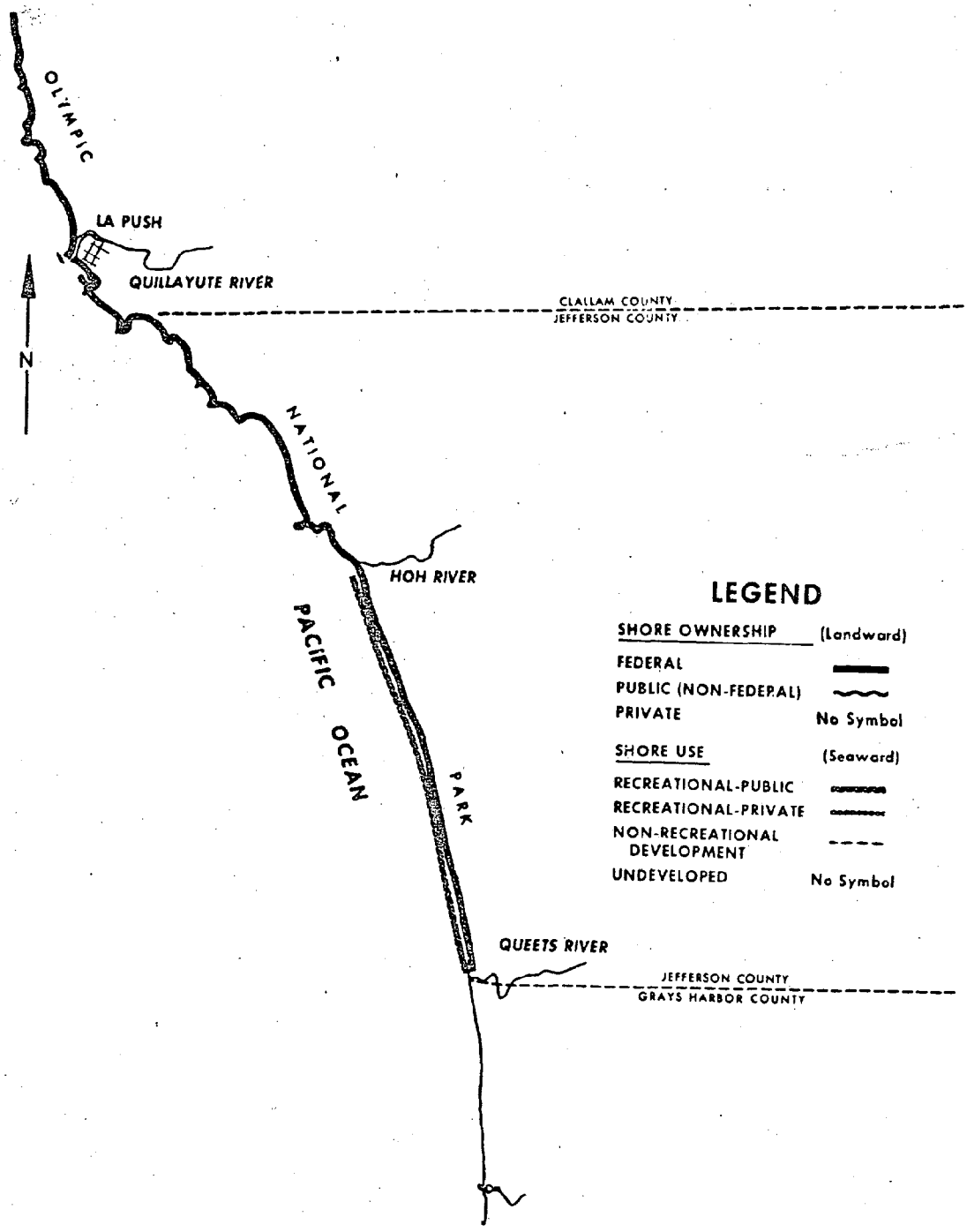
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON

PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. D-10-5-1

PLATE 10A



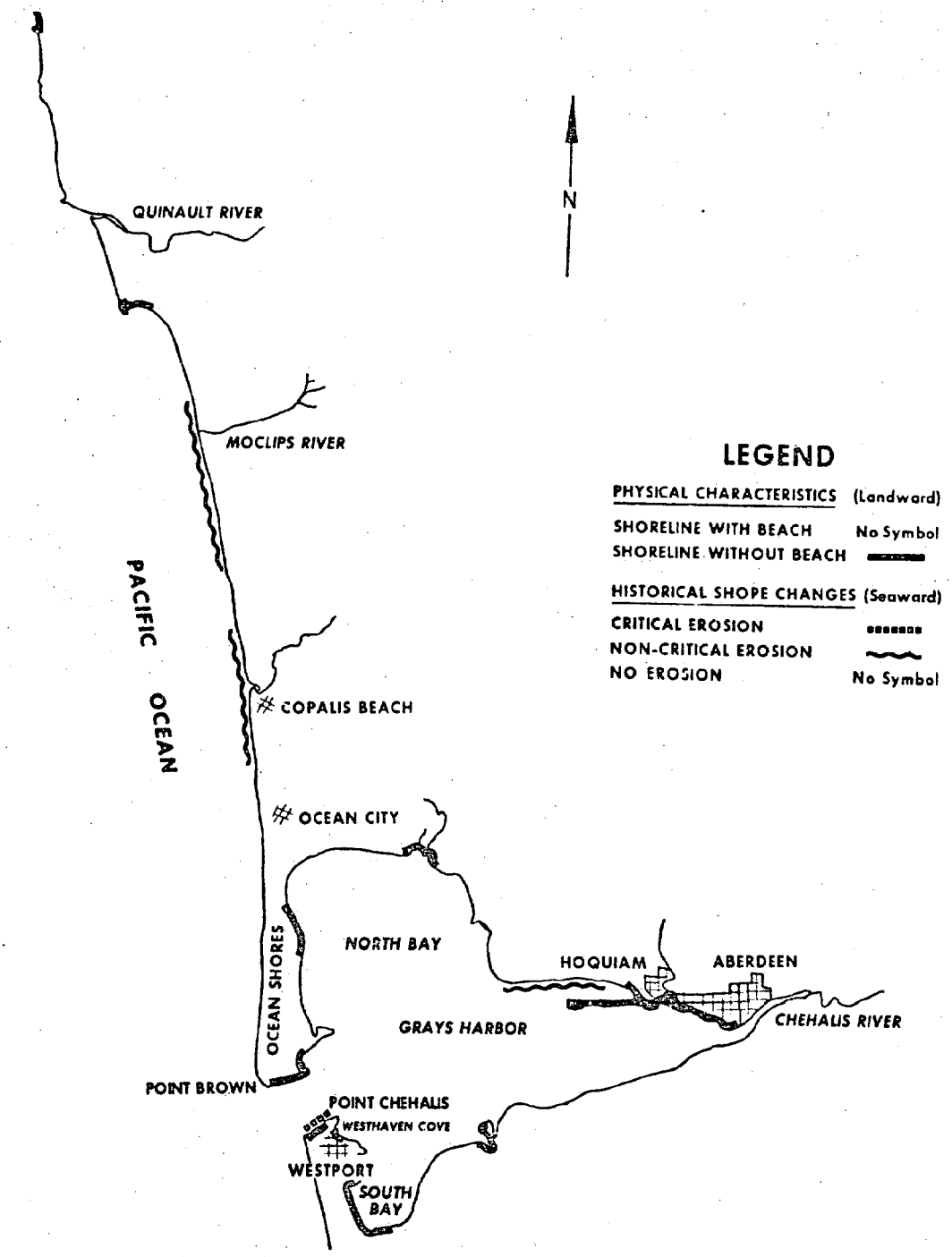
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON

SHORE OWNERSHIP AND SHORE USE

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. D-10-5-1

PLATE 10B



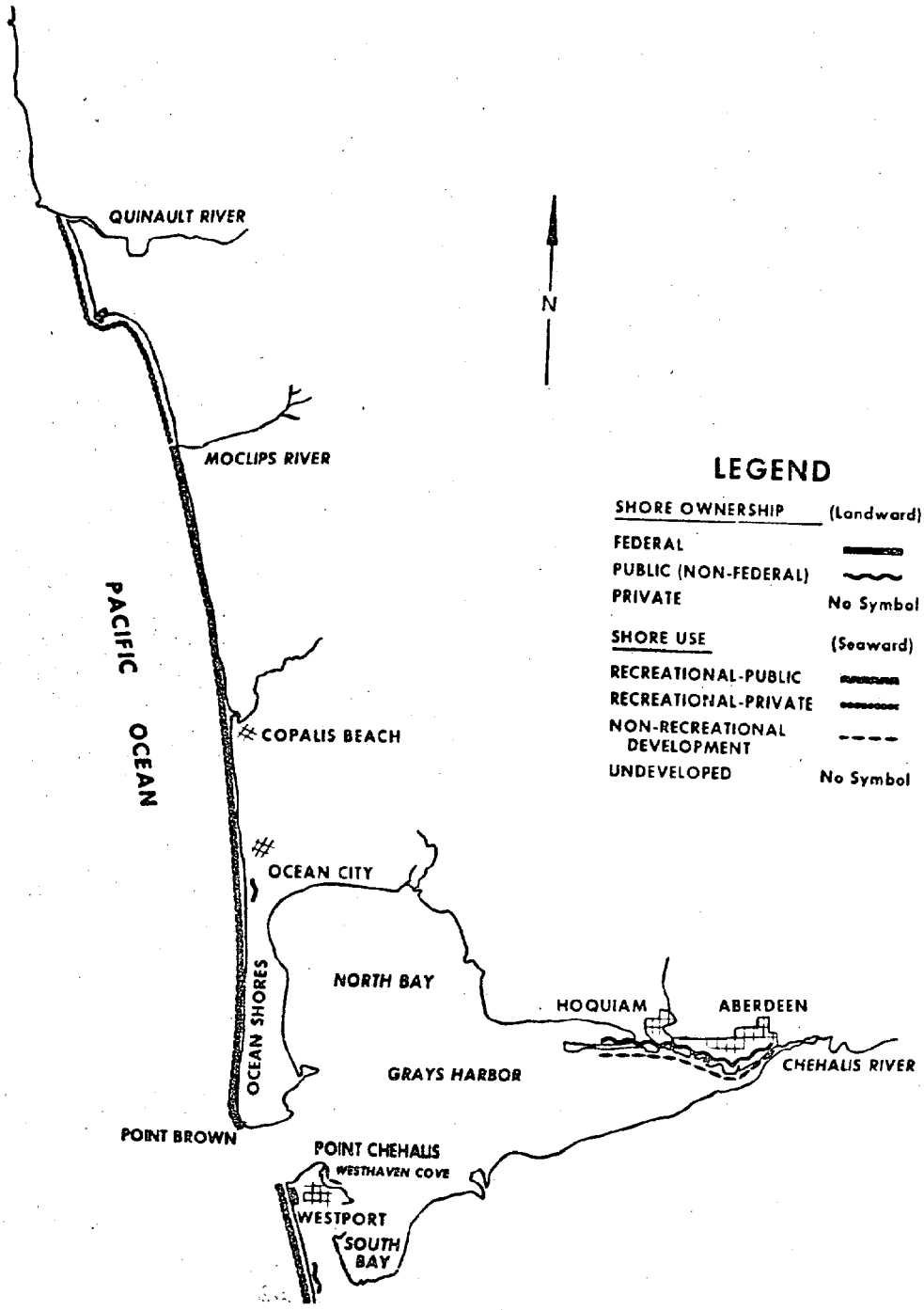
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON

PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. D-10-5-1

PLATE 11A



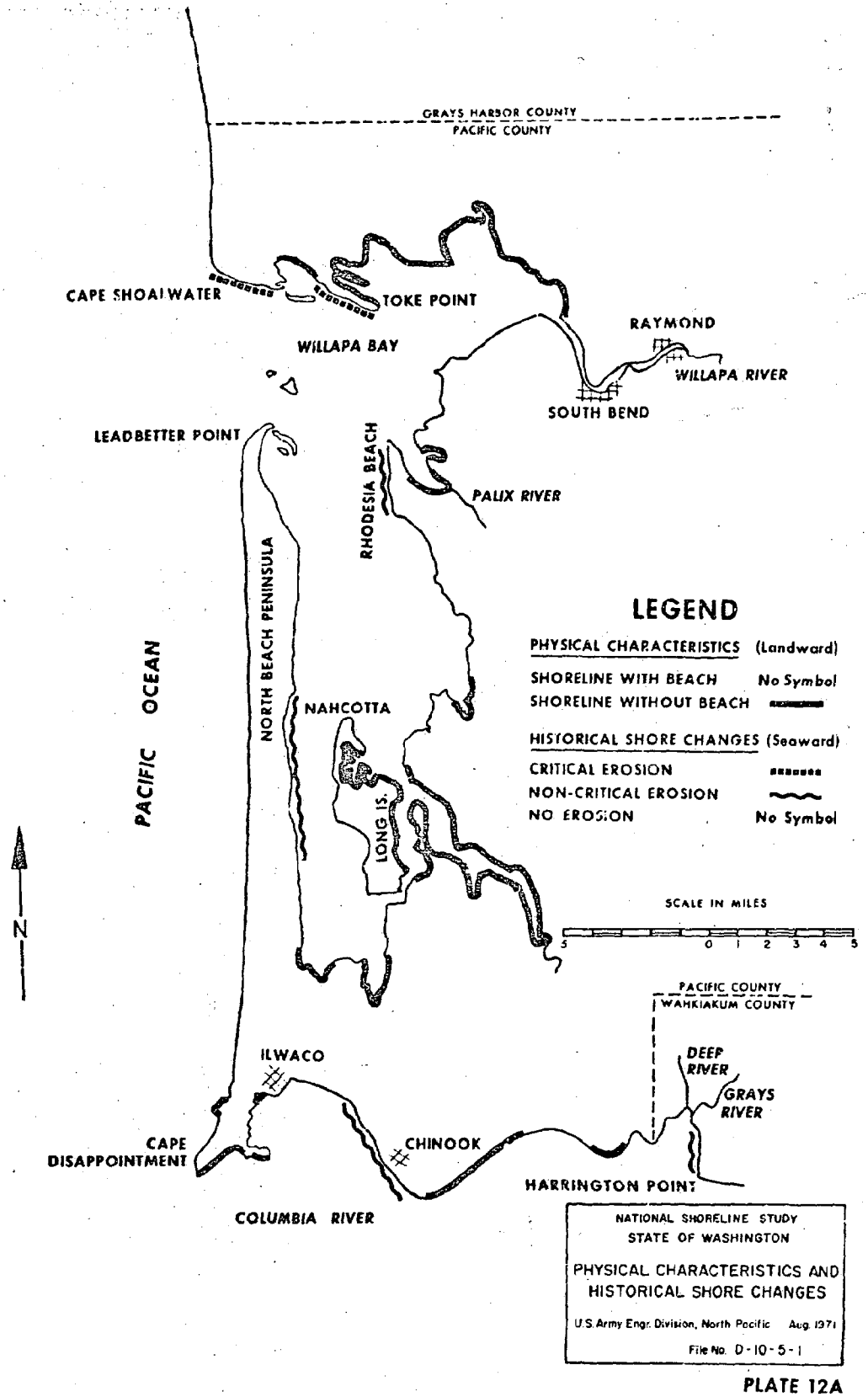
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON

SHORE OWNERSHIP AND SHORE USE

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. D-10-5-1

PLATE 11B



NATIONAL SHORELINE STUDY
STATE OF WASHINGTON

PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. D-10-5-1

PLATE 12A

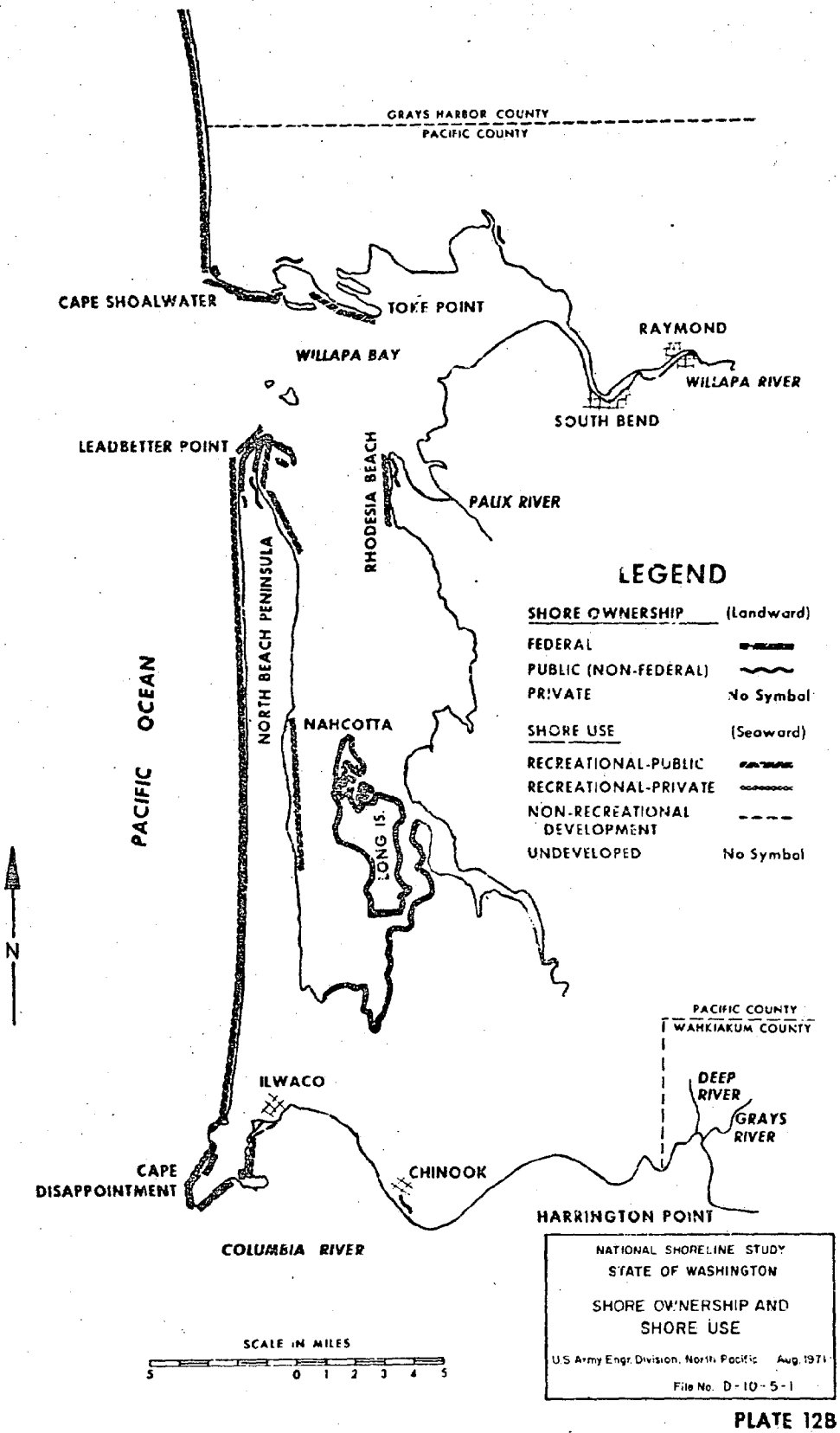

GRAYS HARBOR COUNTY
PACIFIC COUNTY
CAPE SHOALWATER
TOKE POINT
WILLAPA BAY
RAYMOND
WILLAPA RIVER
SOUTH BEND
LEADBETTER POINT
RHODESIA BEACH
PALIX RIVER
NORTH BEACH PENINSULA
PACIFIC OCEAN
NAHCOTTA
LONG IS.
N
PACIFIC COUNTY
WAHKIAKUM COUNTY
ILWACO
DEEP RIVER
GRAYS RIVER
CAPE DISAPPOINTMENT
CHINOOK
HARRINGTON POINT
COLUMBIA RIVER
LEGEND
SHORE OWNERSHIP (Landward)
FEDERAL
PUBLIC (NON-FEDERAL)
PRIVATE No Symbol
SHORE USE (Seaward)
RECREATIONAL-PUBLIC
RECREATIONAL-PRIVATE
NON-RECREATIONAL DEVELOPMENT
UNDEVELOPED No Symbol
SCALE IN MILES
5 0 1 2 3 4 5
NATIONAL SHORELINE STUDY
STATE OF WASHINGTON
SHORE OWNERSHIP AND SHORE USE
U.S. Army Engr. Division, North Pacific Aug. 1971
File No. D-10-5-1

PLATE 12B

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PART 3 - THE OREGON SHORELINE

22. GENERAL

The inventory for the State of Oregon encompasses all shoreline along the Pacific Ocean from the Columbia River, south to the northern border of California, and includes 15 estuaries (see plate 13).

23. PHYSICAL CHARACTERISTICS

Oregon has 500 miles of shoreline comprising 352 miles along the Pacific Ocean and 148 along the 15 estuaries inventoried in this report. Of Oregon's 500 miles of shoreline, 300 miles have beach and 200 miles are without beach, consisting of rocky headlands, marsh areas, bulkheads and revetments.

Classification of Oregon's ocean and bay/estuary shoreline is summarized in table 7. For this report bay/estuary exposure considers the following:

Alsea Bay	Netarts Bay
Chetco River	Rogue River
Columbia River	Siletz Bay
Coos Bay	Siuslaw River
Coquille River	Tillamook Bay
Necanicum River	Umpqua River
Nehalem Bay	Yaquina Bay
Nestucca Bay	

The Oregon coast exhibits a great diversity of shoreline features throughout its length. From Columbia River to a point north of Siuslaw River the shore is composed of many short sand beaches, broken by headlands and bays and estuaries. Extending south from Siuslaw River to a point north of Coos Bay, a distance of approximately 53 miles, the shoreline consists of continuous sand beaches broken only by small streams and the entrance to the Siuslaw and Umpqua Rivers. The area is famous for its large, active sand dunes, some rising to heights of 250 feet or greater. South of Coos Bay to Cape Blanco, the shoreline consists of low cliffs and narrow sand beaches dominated by marine terraces. There are no rock headlands except at Cape Arago, Bandon, and Cape Blanco. Coos Bay and the Coquille River estuary are the only significant embayments in the region. Cliffs and small bays characterize the rugged shoreline south of Cape Blanco. The narrow bay-head beaches are composed of coarse sands and gravels. Most of the Oregon coast is bordered by mountains, with the Oregon coast range extending along the northern portion and the Klamath Mountains along approximately the southern 70 miles. U.S. Highway 101, the Pacific Coast Highway, extends north and south through the State,

PHOTO 10. OREGON COASTLINE SHOWING SHORT BEACHES AND ROCKY HEADLANDS.

TABLE 7
CLASSIFICATION SUMMARY - OREGON

CLASSIFICATIONS	OCEAN SHORELINE EXPOSURE	BAY/ESTUARY SHORELINE EXPOSURE	TOTAL SHORELINE SHORELINE EXPOSURE
MILES OF SHORELINE	352.0 Miles	148.0 Miles	500.0 Miles
PHYSICAL CHARACTERISTICS			
Shoreline without Beach	96.0	104.0	200.0
Shoreline with Beach	256.0	44.0	300.0
HISTORICAL SHORE CHANGES			
Critical Erosion	58.5	5.5	64.0
Non-Critical Erosion	92.5	9.0	101.5
No Erosion	201.0	133.5	334.5
SHORELINE OWNERSHIP			
Federal	66.0	16.7	82.7
Public (Non-Federal)	128.5	29.5	158.0
Private	157.5	80.5	238.0
Uncertain	0.0	21.3	21.3
SHORE USE			
Recreational-Public	171.0	34.2	205.2
Recreation-Private	79.0	2.3	81.3
Non-Recreational Development	34.0	76.0	110.0
Undeveloped	68.0	35.5	103.5

generally following the coastline. The major estuaries and bays are: Columbia River, Tillamook Bay, Yaquina Bay, Alsea Bay, Siuslaw River, Umpqua River, and Coos Bay.

24. HISTORIC SHORE CHANGES

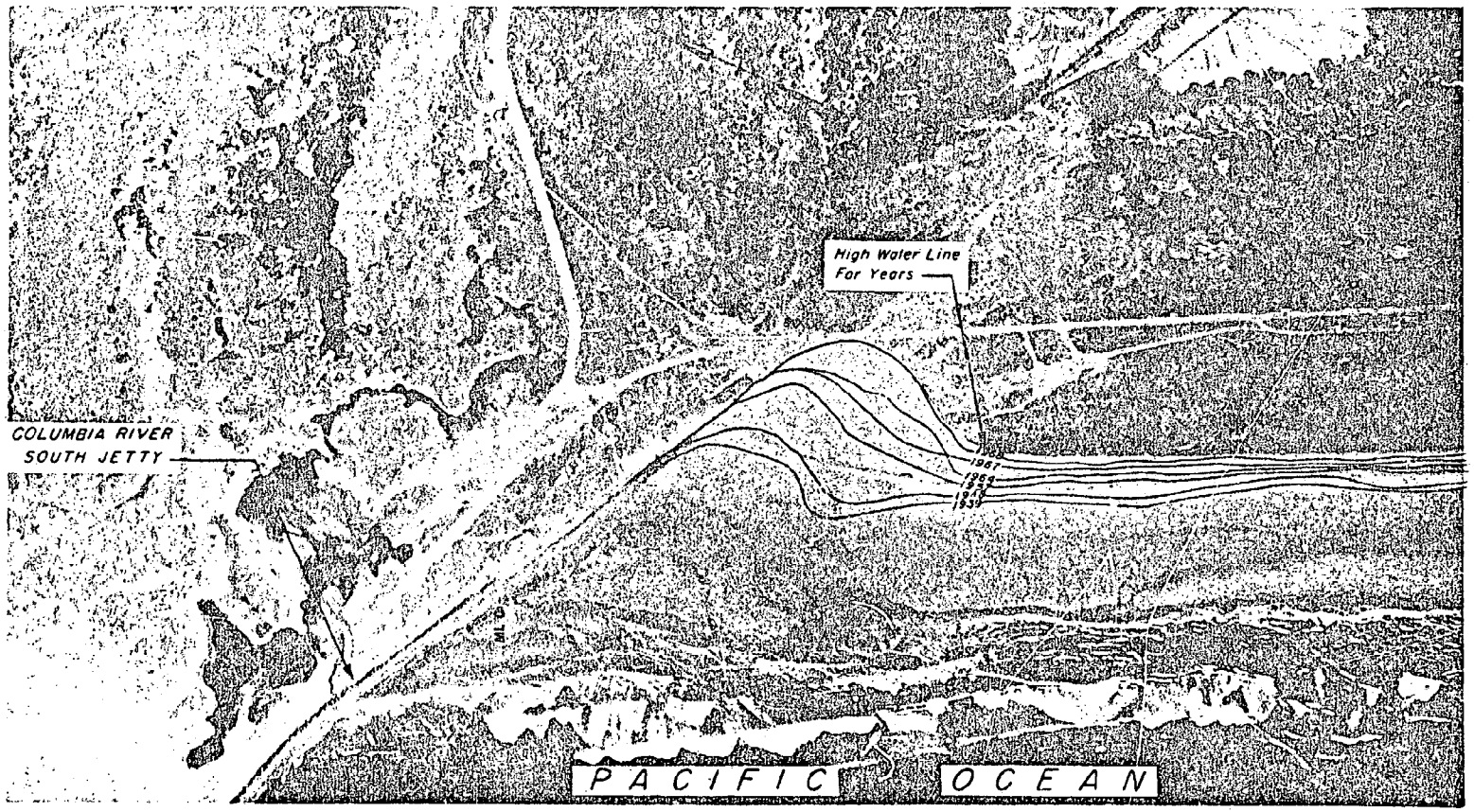
The inventory of historic shore changes shows 165.5 miles of Oregon shoreline that are eroding. Of this total 64 miles are critical and 101.5 miles have a history of noncritical erosion. The remaining 334.5 miles of shoreline are either stable or accreting (see table 7). A short length of the bankline on the south side of the Columbia River estuary, upstream of the town of Hammond, Oregon, has a minor erosion problem. The Oregon State Park Commission reports some erosion along the east side of the sandspit separating Nehalem Bay from the ocean. The erosion is not considered a serious problem and the area is not developed although it is included in a State park. The State has previously placed some stone revetment in an area near the park's boat-launching ramp. Tillamook Bay, Siuslaw River, and Necanicum River have erosion problems which will require some type of remedial action to prevent further economic loss.

Portland District, Corps of Engineers has conducted surveillance programs for two areas--Clatsop Beach and Bayocean Peninsula--to monitor erosion problems.

The Clatsop Beach study area encompasses about 18 miles of the Oregon shoreline lying between the Columbia River south jetty and Tillamook Head, south of the city of Seaside. Comparison of the high waterline for the years 1939 through 1968 shows that erosion occurred from the shoreline at the south jetty to a nodal point about 3 miles south, but accretion occurred from this point to Tillamook Head, see figures 3 through 10. Maximum erosion, approximately 790 feet, occurred adjacent to the south jetty; maximum accretion, about 208 feet, occurred at Necanicum River about 14.7 miles from the south jetty. Averaged over the entire beachline, the rates of erosion and accretion were about 6 and 7 feet per year, respectively. Figure 11 shows shoreline cross sections of the Clatsop Beach area.

Bayocean Peninsula is a natural barrier about 4 miles in length separating Tillamook Bay and the Pacific Ocean (see figure 12). Prior to November 1952 the spit varied in width between high waterlines from 300 feet near the southerly end to 3,300 feet at a point 1 mile from the northerly end. Elevations varied from 17 feet above mean lower low water on a sandy gravel and boulder formation at the south end to 140 feet on the highest dunes located near the middle of the peninsula. About 1907 a resort area was started on Bayocean Peninsula. In the beginning the area consisted of summer cottages but by 1909 a hotel and natatorium had been constructed. Legal difficulties forced the operating company into bankruptcy in 1915 and the resort was closed. It was reopened in 1928 but little development followed.

(Text resumes on page 61)



NOTES

HIGH WATER LINE IS THE TOE OF THE BANK LINE.

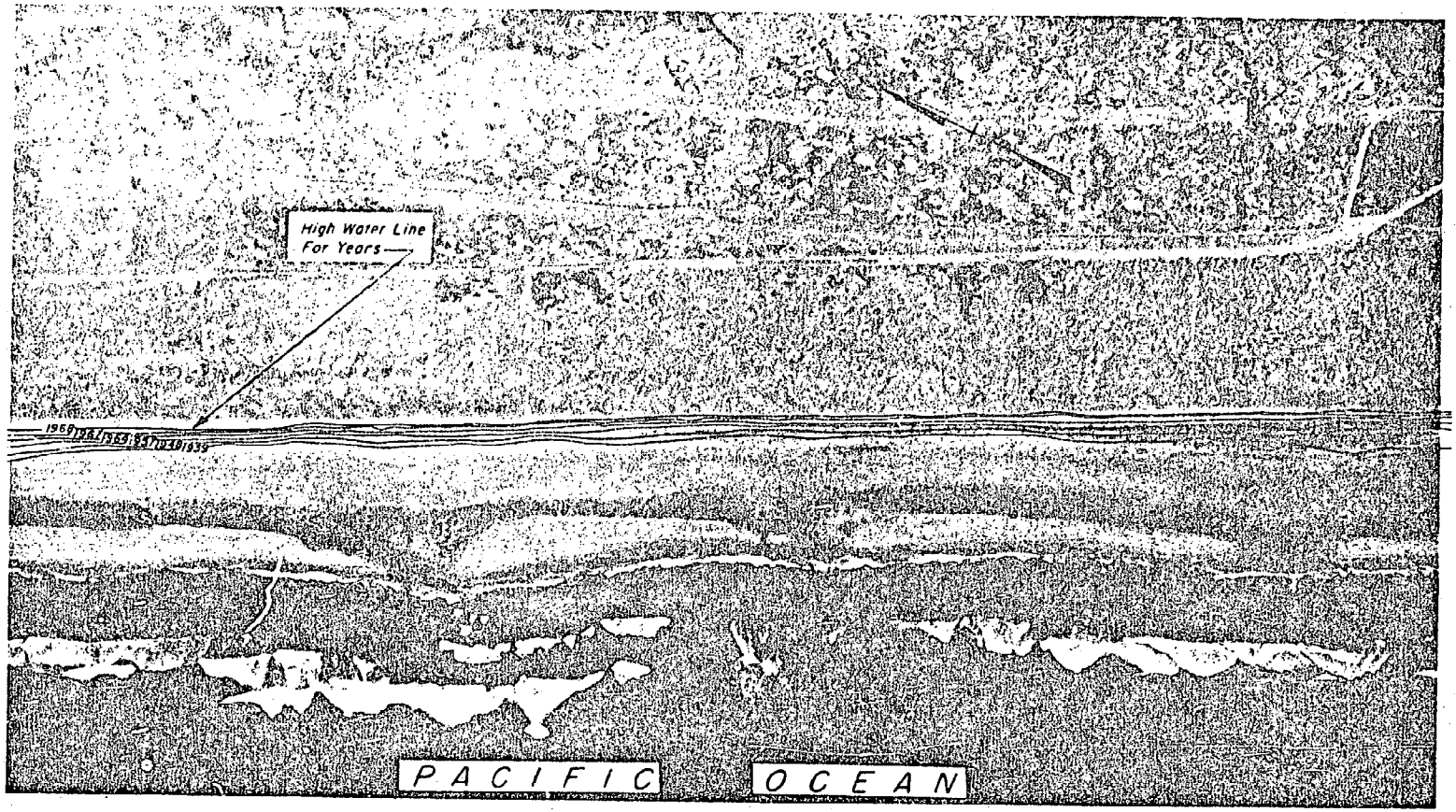
DATE OF AERIAL PHOTOGRAPHY, 16 MAY 1968.

FIGURE 3 PHOTO 11

COLUMBIA RIVER AT MOUTH

CLATSOP BEACH SURVEILLANCE PROGRAM

PREPARED SEPT. 1968



NOTES

HIGH WATER LINE IS THE TOE OF THE BANK LINE.

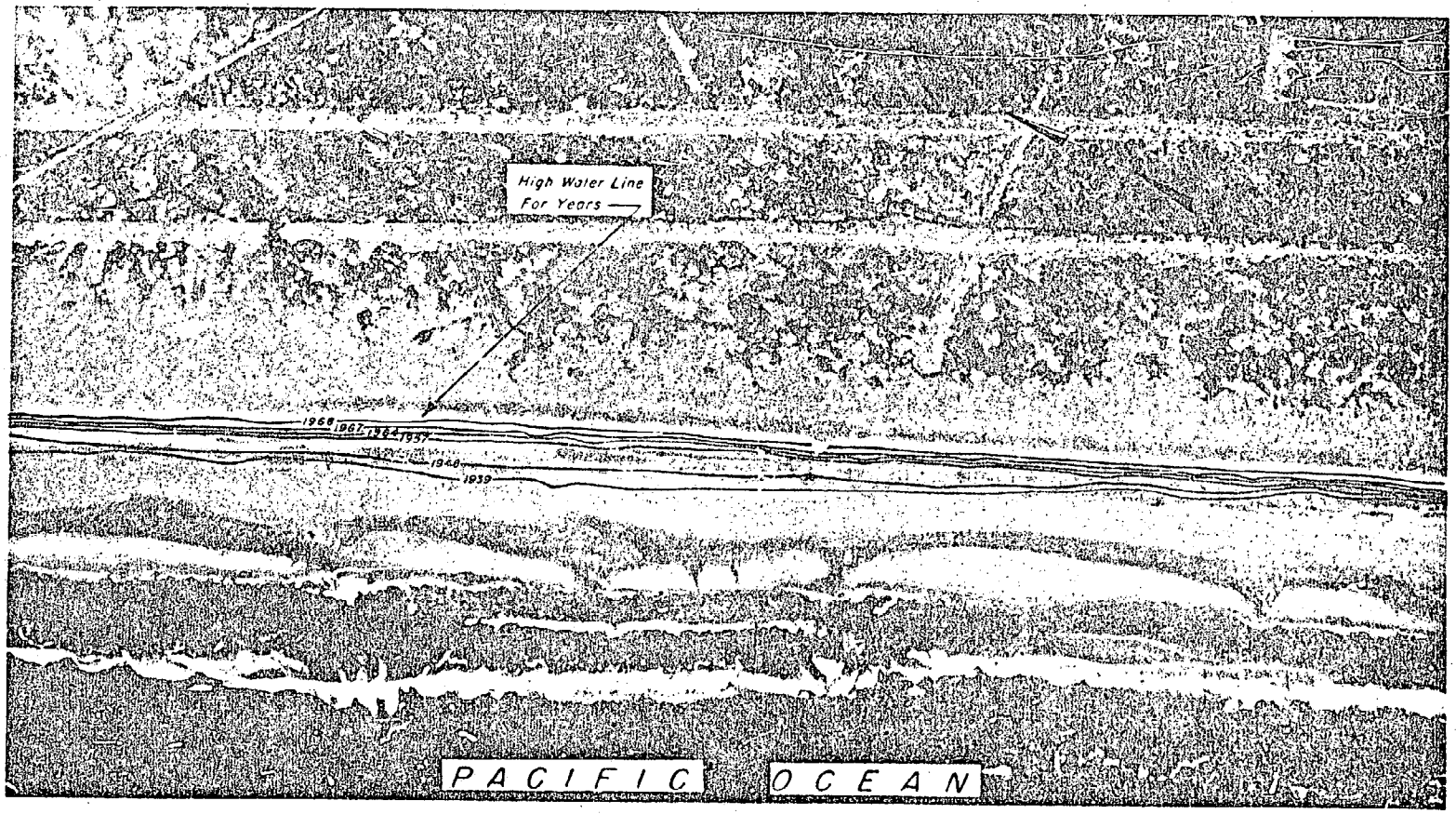
DATE OF AERIAL PHOTOGRAPHY, 16 MAY 1968.

FIGURE 4 PHOTO 12

COLUMBIA RIVER AT MOUTH

CLATSOP BEACH SURVEILLANCE PROGRAM

PREPARED SEPT. 1968



NOTES

HIGH WATER LINE IS THE TOE OF THE BANK LINE.

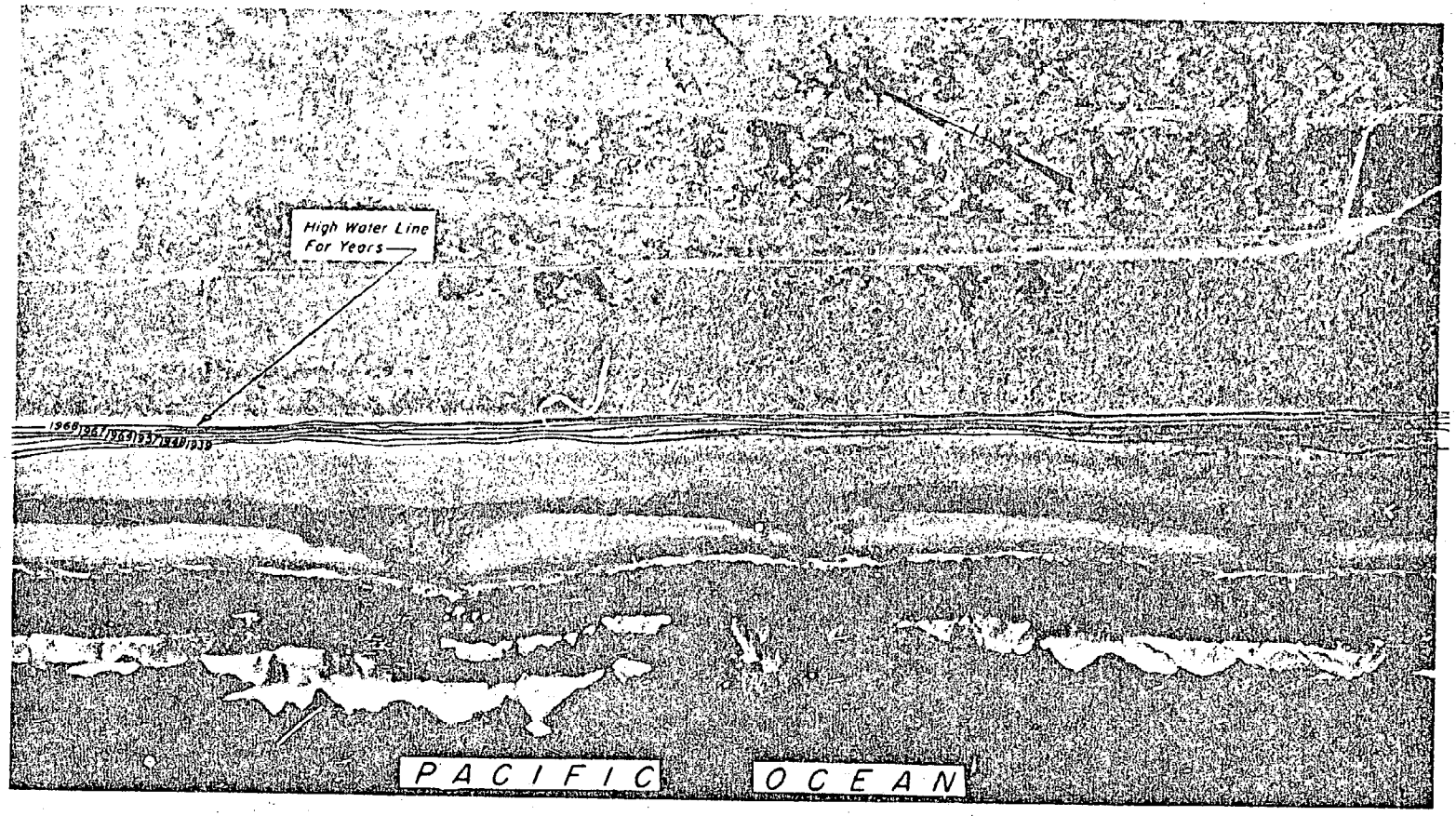
DATE OF AERIAL PHOTOGRAPHY, 16 MAY 1968.

FIGURE 5 PHOTO 13

COLUMBIA RIVER AT MOUTH

CLATSOP BEACH SURVEILLANCE PROGRAM

PREPARED SEPT. 1968



NOTES

HIGH WATER LINE IS THE TOE OF THE BANK LINE.

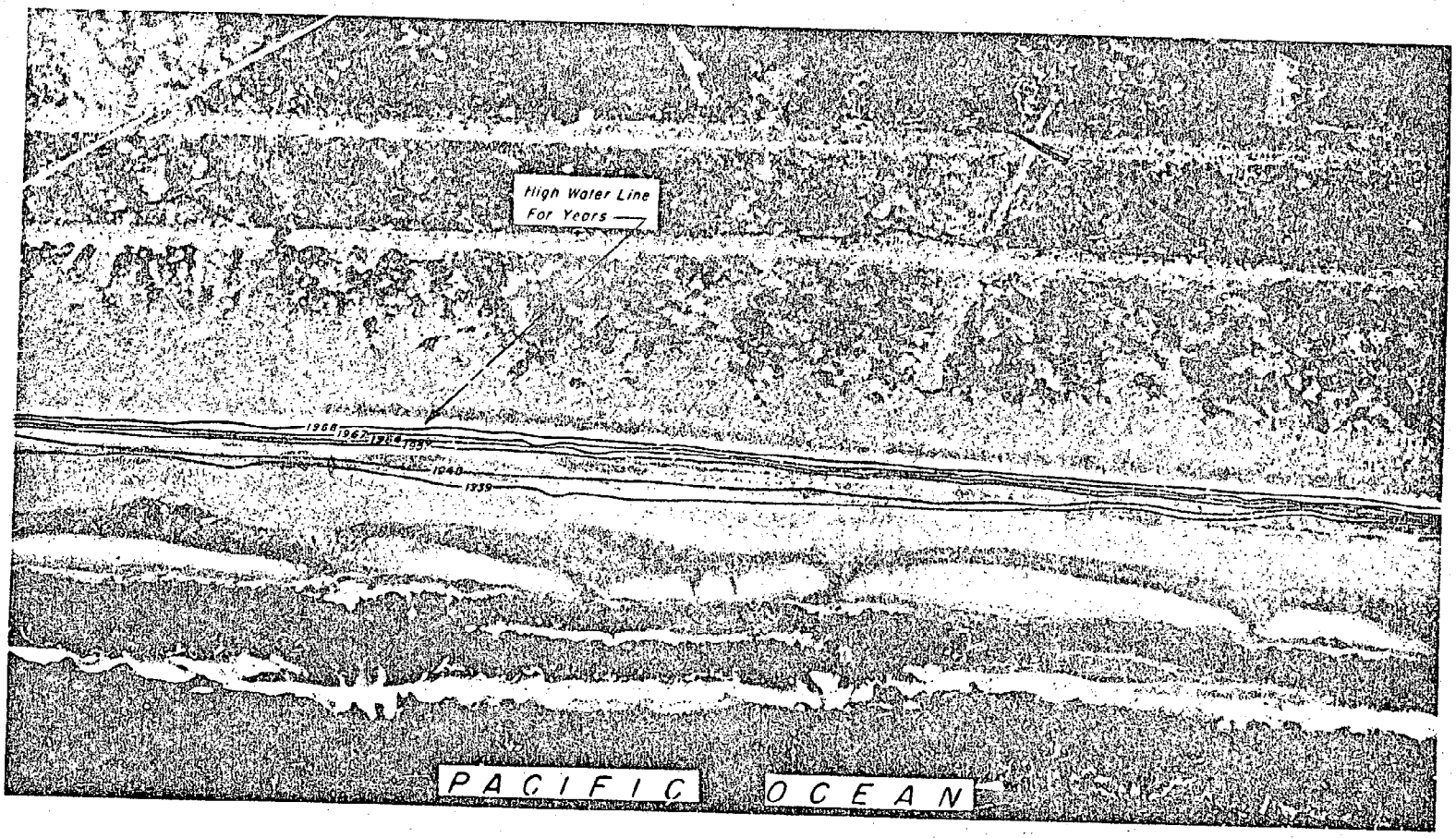
DATE OF AERIAL PHOTOGRAPHY, 16 MAY 1968.

FIGURE 4 PHOTO 12

COLUMBIA RIVER AT MOUTH

CLATSOP BEACH SURVEILLANCE PROGRAM

PREPARED SEPT. 1968



NOTES

HIGH WATER LINE IS THE TOE OF THE BANK LINE.

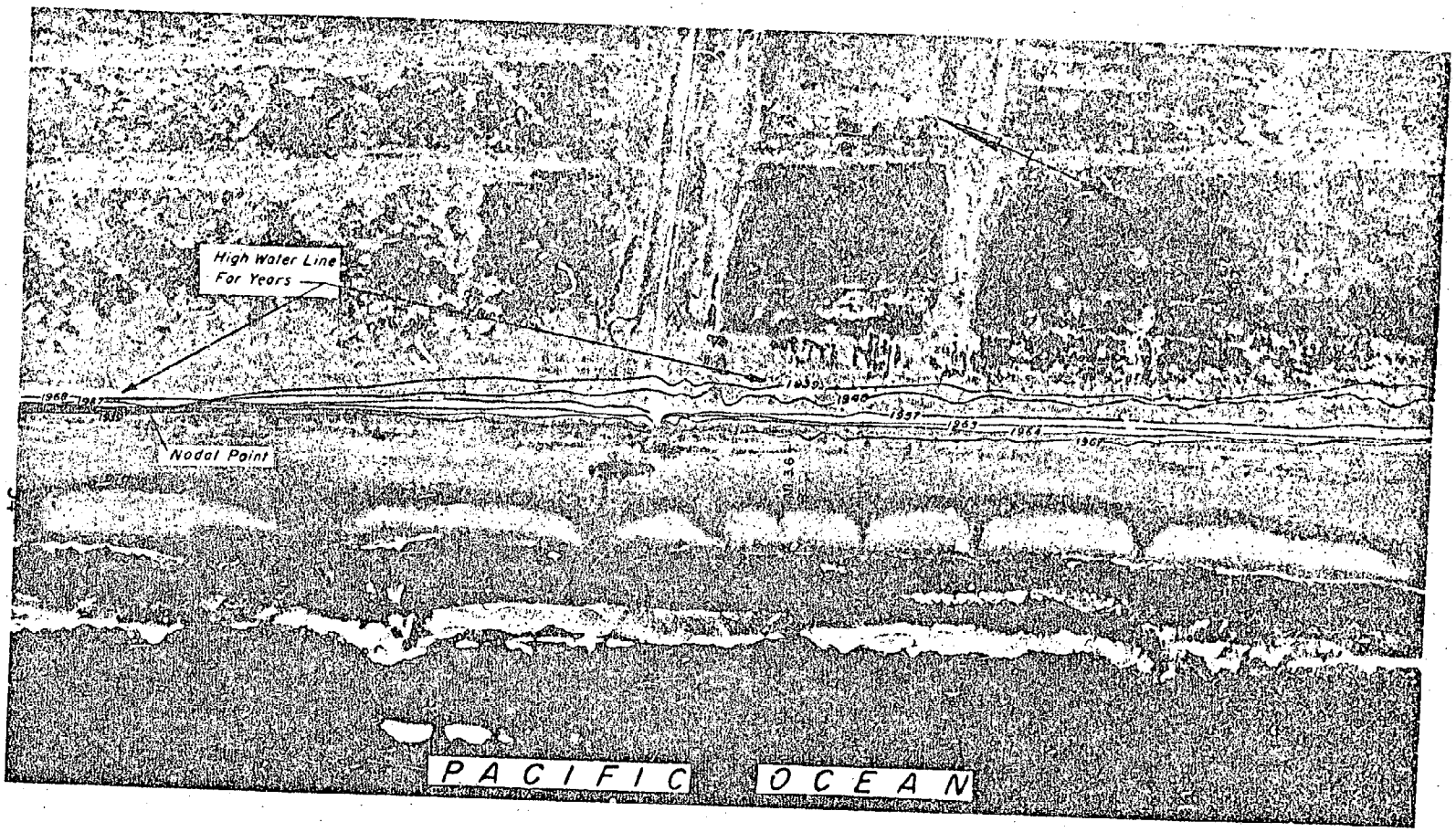
DATE OF AERIAL PHOTOGRAPHY, 16 MAY 1968.

FIGURE 5 PHOTO 13

COLUMBIA RIVER AT MOUTH

CLATSOP BEACH SURVEILLANCE PROGRAM

PREPARED SEPT. 1968.



NOTES

HIGH WATER LINE IS THE TOE OF THE BANK LINE.

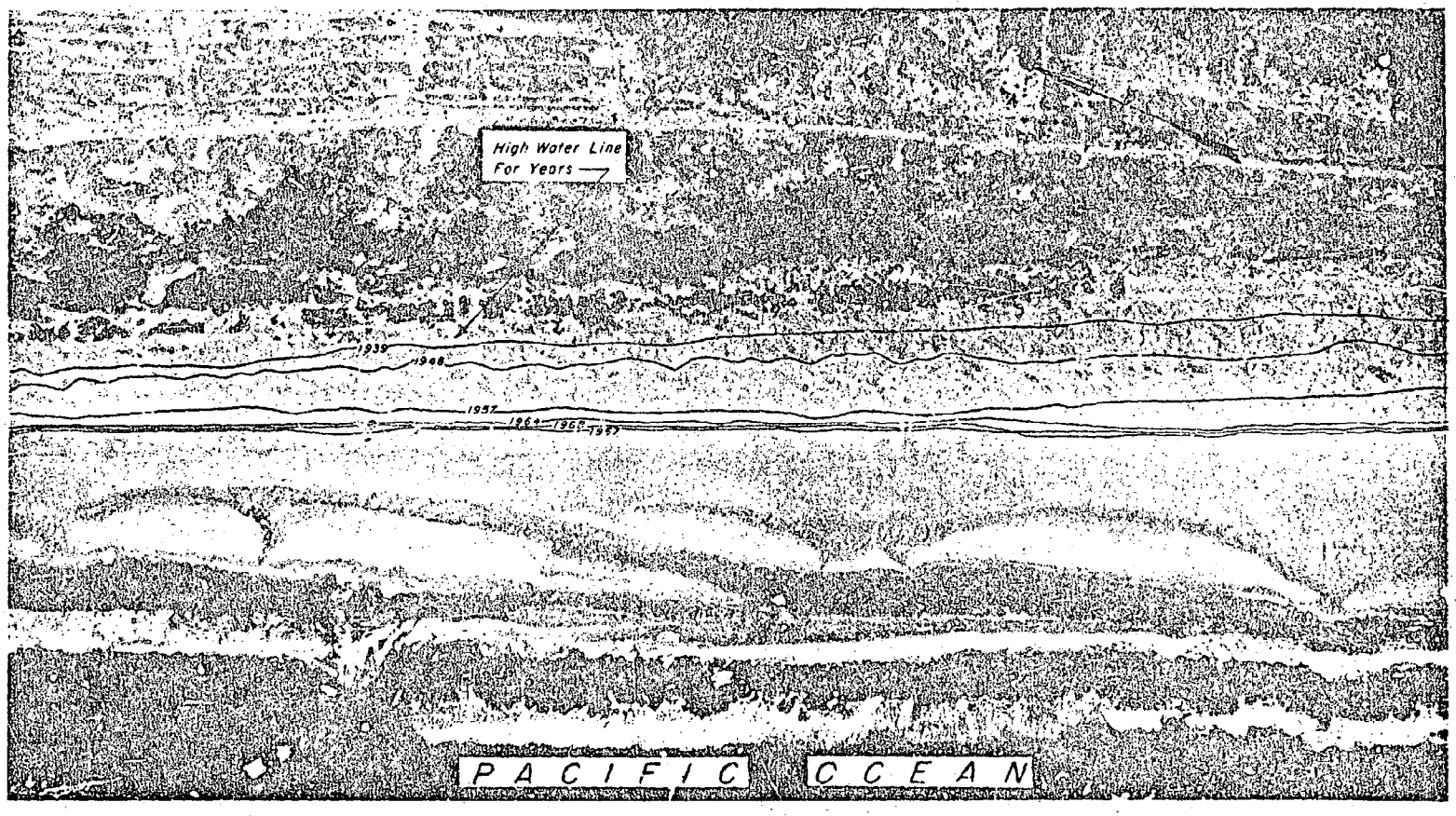
DATE OF AERIAL PHOTOGRAPHY, 16 MAY 1968.

FIGURE 6 PHOTO 14

COLUMBIA RIVER AT MOUTH

CLATSOP BEACH SURVEILLANCE PROGRAM

PREPARED SEPT. 1968



NOTES

HIGH WATER LINE IS THE TOE OF THE BANK LINE.

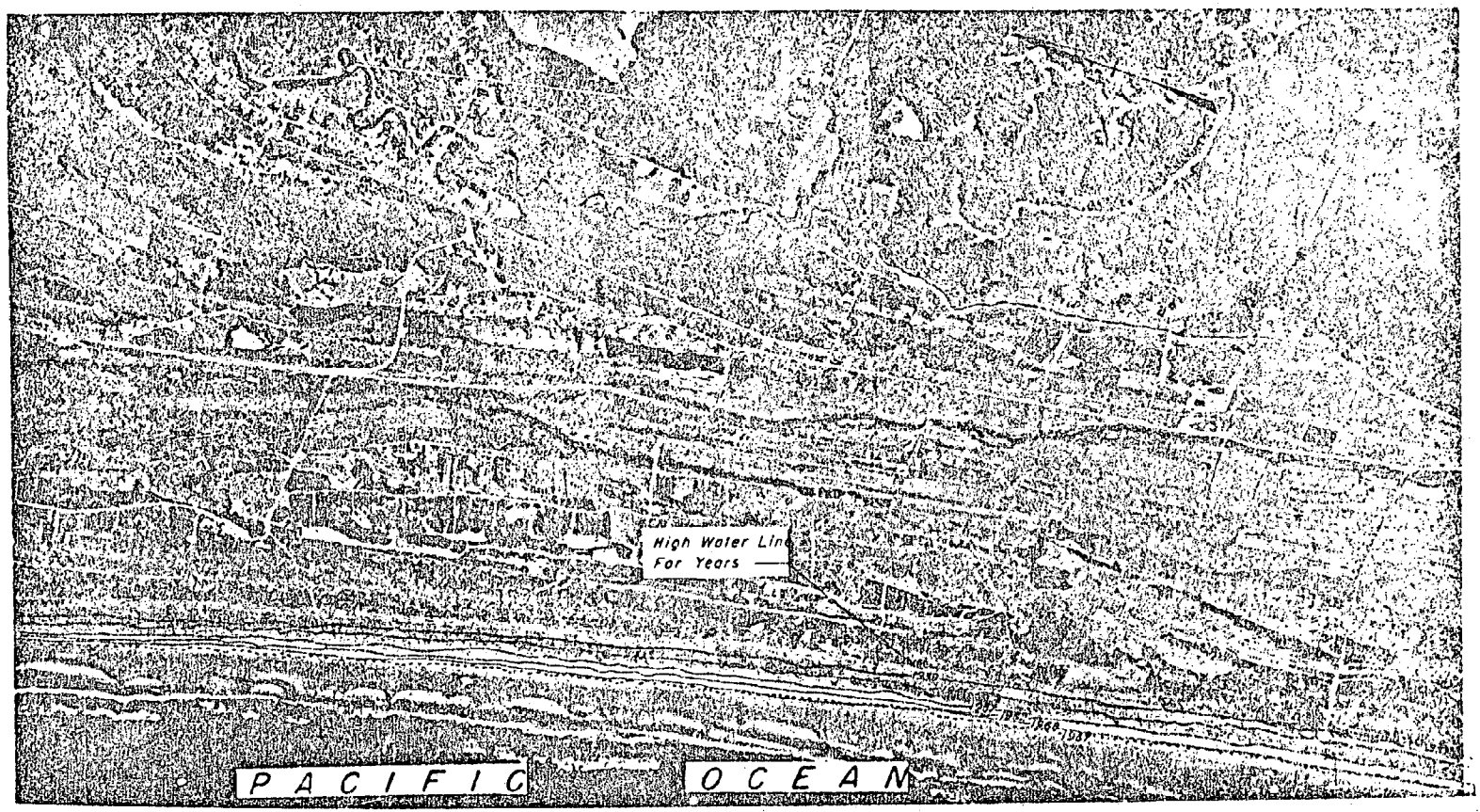
DATE OF AERIAL PHOTOGRAPHY, 16 MAY 1968.

FIGURE 7 PHOTO 15

COLUMBIA RIVER AT MOUTH

CLATSOP BEACH SURVEILLANCE PROGRAM

PREPARED SEPT. 1968



NOTES

HIGH WATER LINE IS THE TOE OF THE BANK LINE.

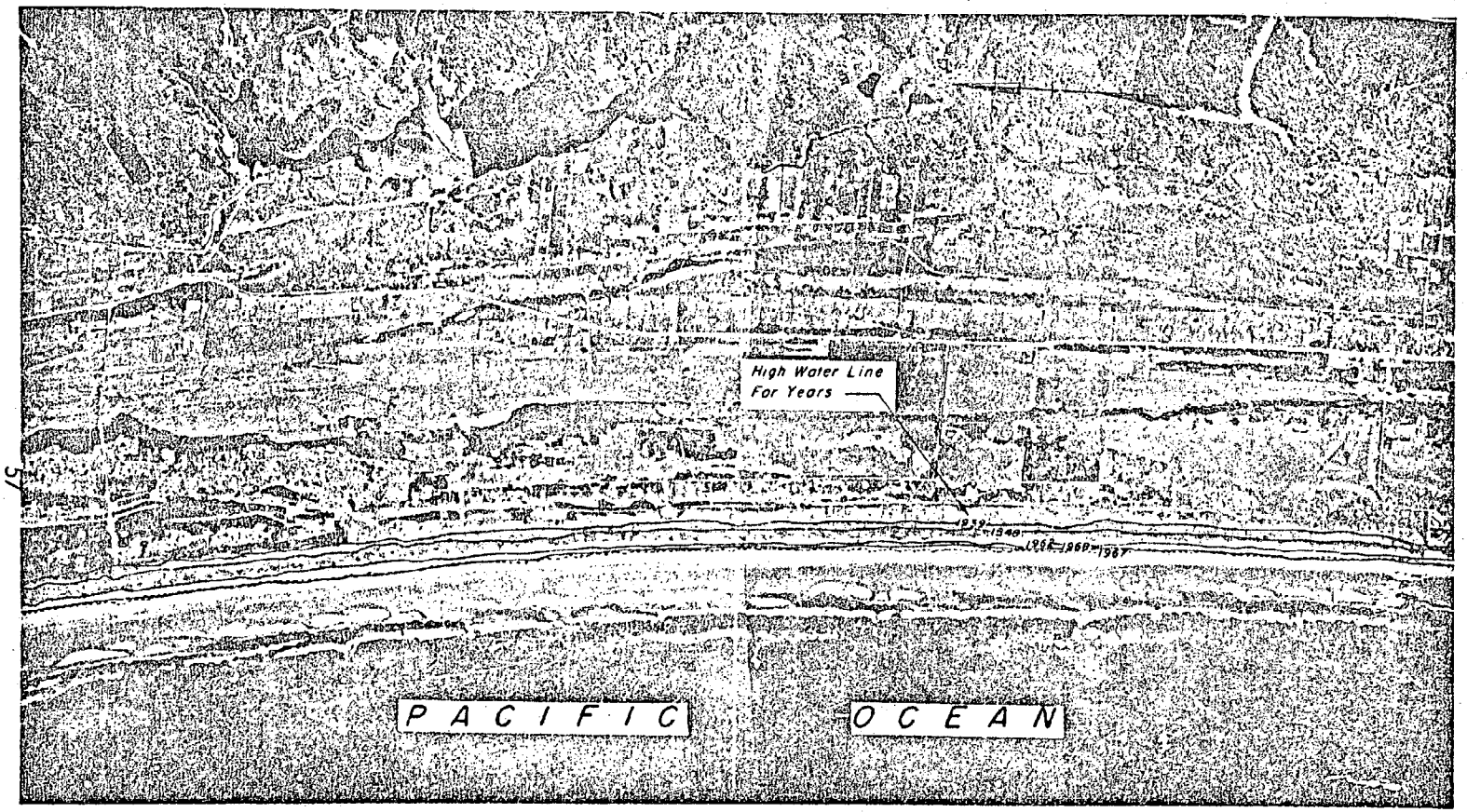
DATE OF AERIAL PHOTOGRAPHY, 16 MAY 1968.

FIGURE 8

COLUMBIA RIVER AT MOUTH

CLATSOP BEACH SURVEILLANCE PROGRAM

PREPARED SEPT. 1968



NOTES

HIGH WATER LINE IS THE TOE OF THE BANK LINE.

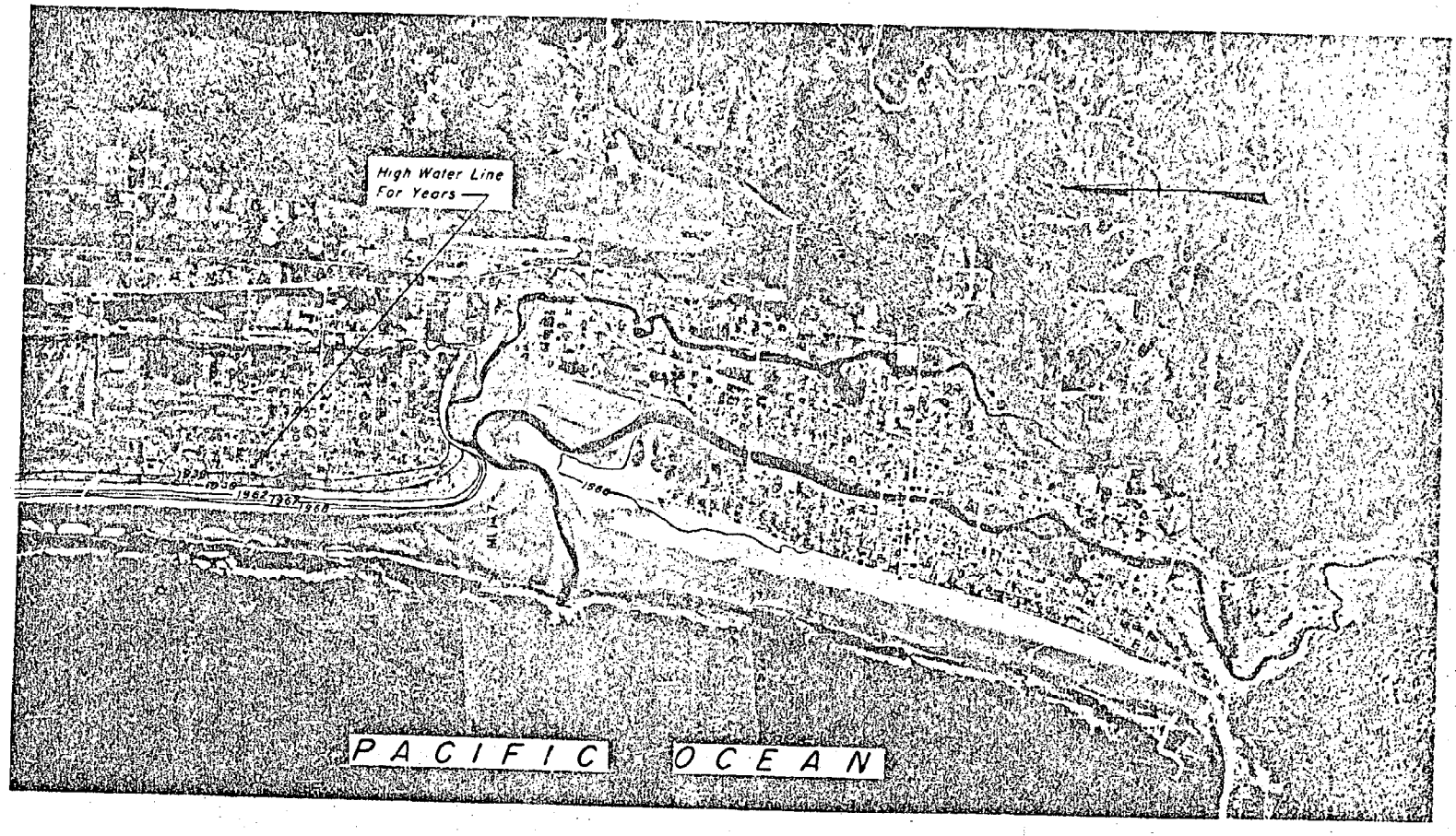
DATE OF AERIAL PHOTOGRAPHY, 16 MAY 1968.

FIGURE 9

COLUMBIA RIVER AT MOUTH

CLATSOP BEACH SURVEILLANCE PROGRAM

PREPARED SEPT. 1968



NOTES

HIGH WATER LINE IS THE TOE OF THE BANK LINE.

DATE OF AERIAL PHOTOGRAPHY, 16 MAY 1968.

FIGURE 10

COLUMBIA RIVER AT MOUTH

CLATSOP BEACH SURVEILLANCE PROGRAM

PREPARED SEPT. 1968

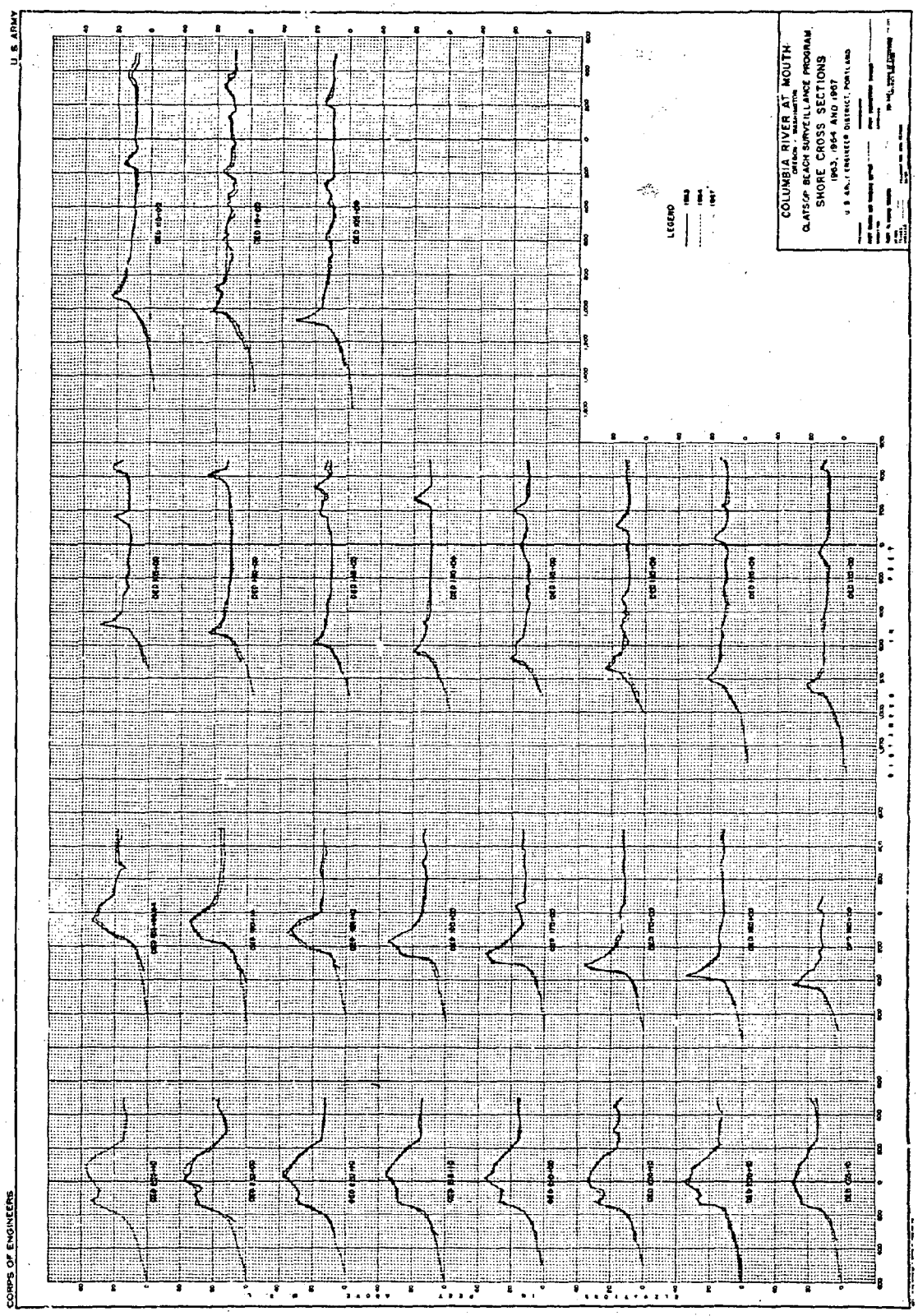

U.S. ARMY
CORPS OF ENGINEERS
COLUMBIA RIVER AT MOUTH
OREGON - WASHINGTON
CLATSOP BEACH SURVEILLANCE PROGRAM
SHORE CROSS SECTIONS
1963, 1964 AND 1967
U.S. ARMY ENGINEER DISTRICT, PORTLAND
LEGEND
1963
1964
1967

FIGURE 11

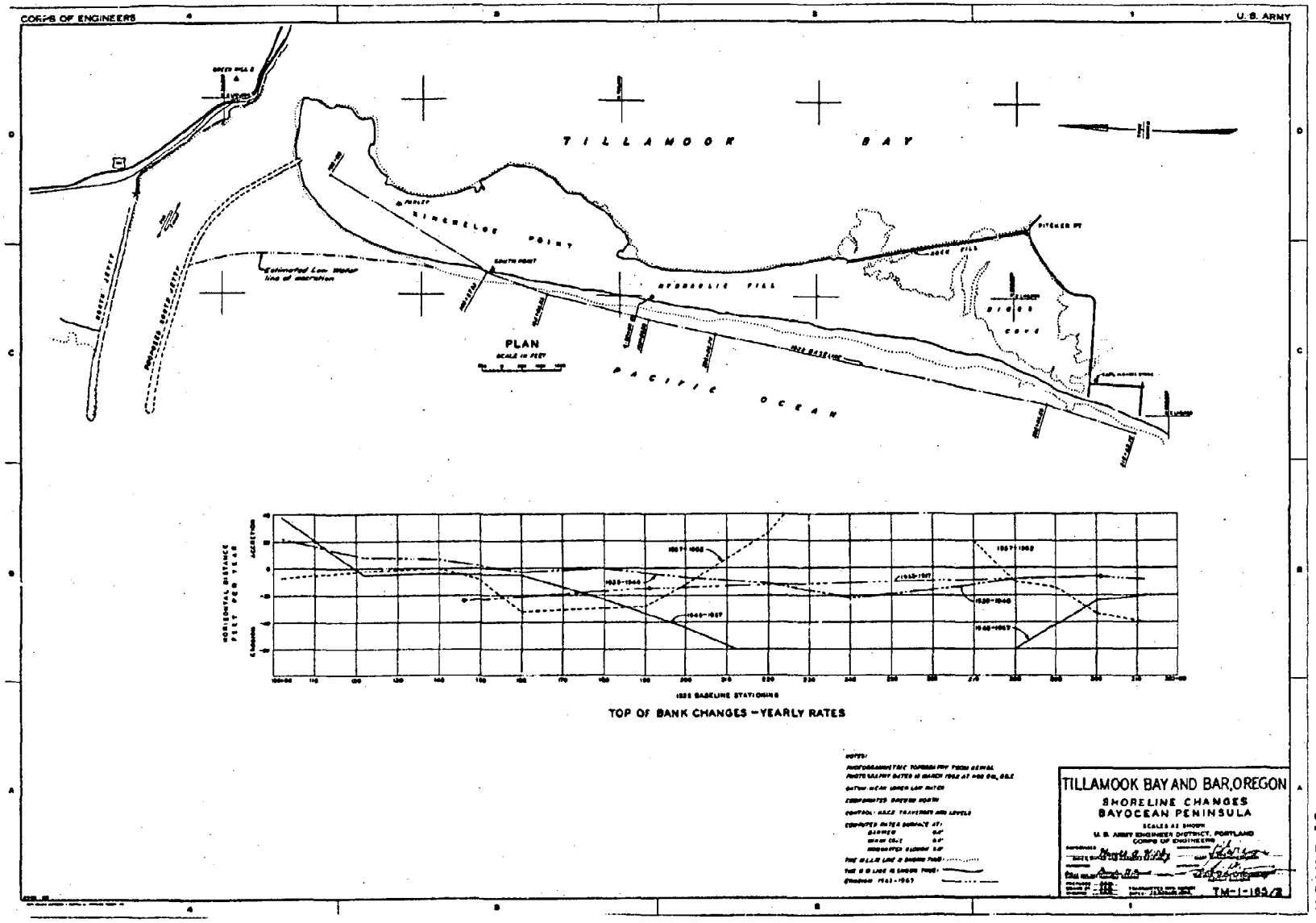

CORPS OF ENGINEERS
U.S. ARMY
TILLAMOOK BAY
PACIFIC OCEAN
PLAN
TOP OF BANK CHANGES – YEARLY RATES
TILLAMOOK BAY AND BAR, OREGON
SHORELINE CHANGES
BAYOCEAN PENINSULA
U.S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS
TM-1-182/2

FIGURE 12

Heavy storms destroyed the natatorium in 1932, and erosion along the peninsula became an increasing problem. The area was eventually abandoned. In November 1952 severe storm waves, in combination with higher than ordinary tides, breached the narrow southern portion of the peninsula. Records of observations indicate significant offshore changes occurred during the period 1885 to 1927. Approximately 44 million cubic yards were eroded between the low waterline and the 10-fathom line for a distance of 6 miles from Cape Meares north to the bay entrance. During this same period, 91 million cubic yards of material were eroded, generally between the 10- and 20-fathom lines, in the reach of the coast extending 10 miles south of Cape Meares. The increased depths offshore allowed higher waves to approach and attack the beach. Shoreline changes on the peninsula have been monitored since 1939 (see photos 11 through 15), and the data reveal an increase in erosion along the southerly end of the spit prior to the breach in 1952. Subsequent to completion of the closure structure in 1956, erosion has decreased in that area but has become more severe along an area extending north. The tabulation below illustrates this.

TABLE 8
TOP OF BANK CHANGES - BAYOCEAN PENINSULA
Yearly Rates of Selected Stations
(period 1939-1967)

Period	Amount of accretion (+) or erosion (-) (feet per year)		
	Station 146 1/	Station 190 1/	Station 280 1/
1939-46	+4	-4	-8
1946-57	-4	-34	-60
1957-62	-4	-28	-10
1962-67	-24	-15	-8

1/ See figure 12 for location of stations.

25. LITTORAL DRIFT

Wave action and littoral transport of sediments along Oregon's Pacific Ocean shoreline shift direction seasonally. The most severe wave action is from the southwest. Waves from the northwest are less severe but prevail for a longer period of time.

Little is known about the direction of littoral transport of sediments along Oregon's shoreline. The severe wave action from the southwest would point to a predominant south to north transport of littoral material. However, there is a net less of foreshore sediments associated with the waves from the southwest and a net gain of

(Text resumes on page 67)

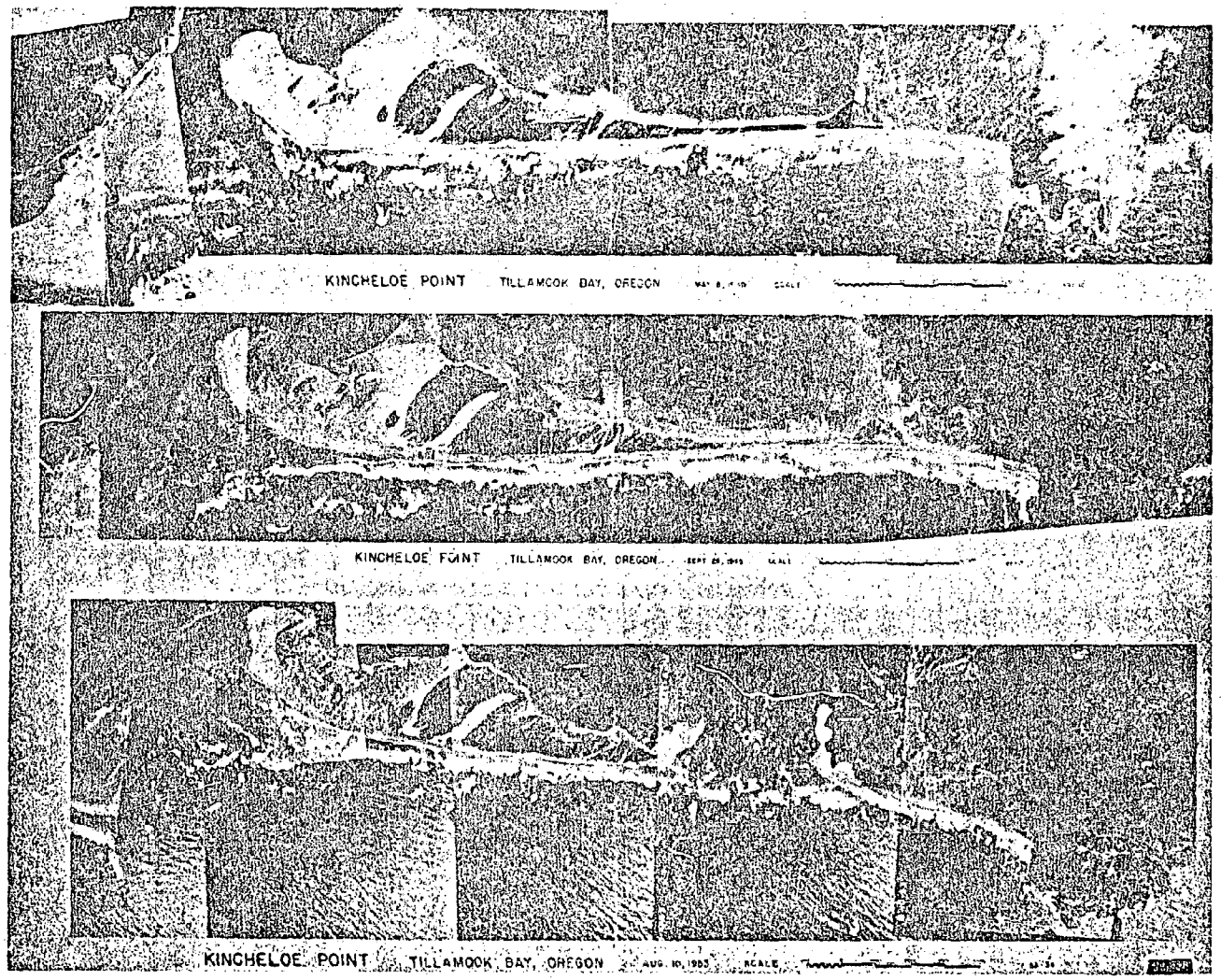


PHOTO 11. BAYOCEAN PENINSULA, TILLAMOOK BAY, OREGON - AERIAL PHOTOGRAPHS 1939-1953

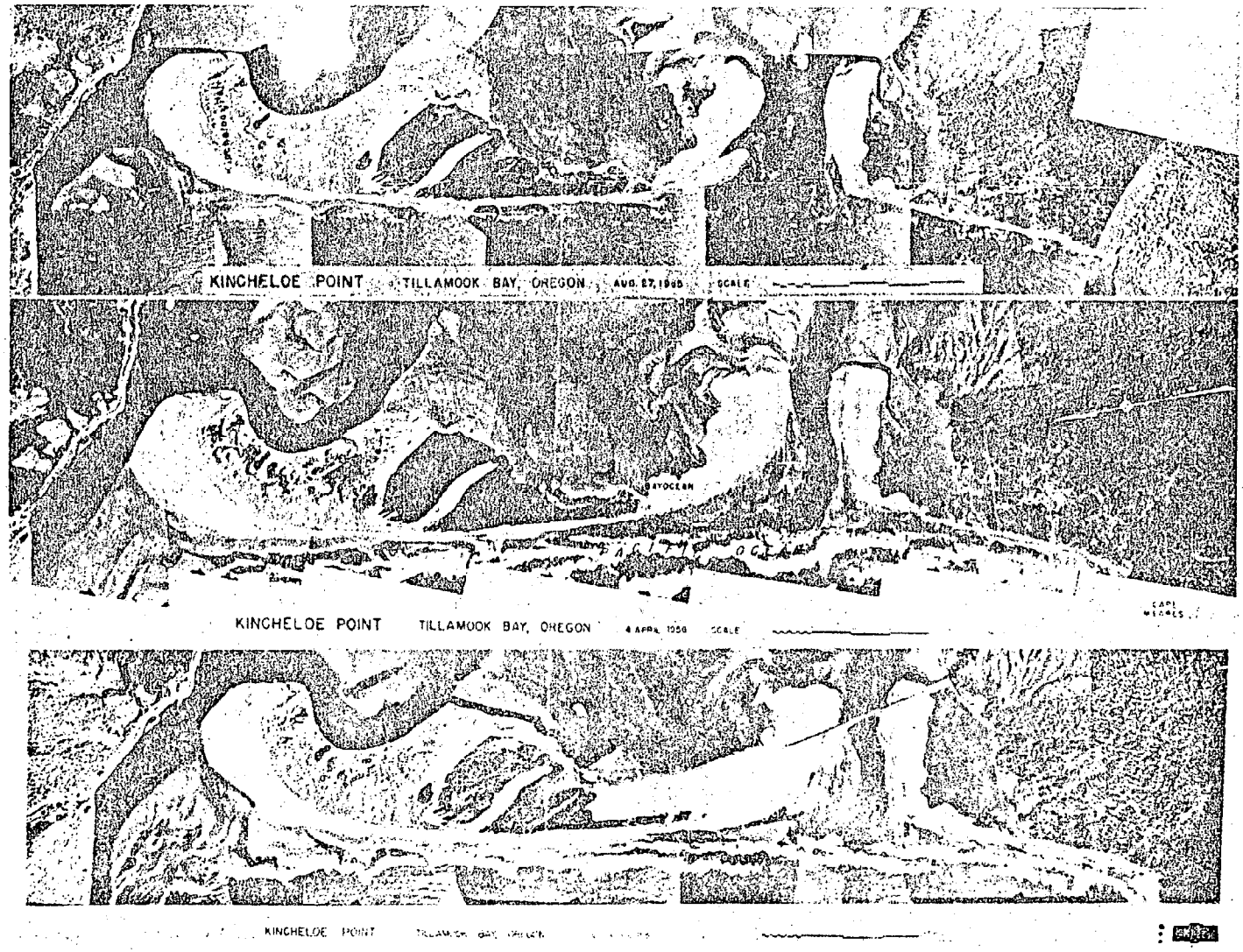


PHOTO 12. BAYOCEAN PENINSULA, TILLAMOOK BAY, OREGON - AERIAL PHOTOGRAPHS
1955 and 1956

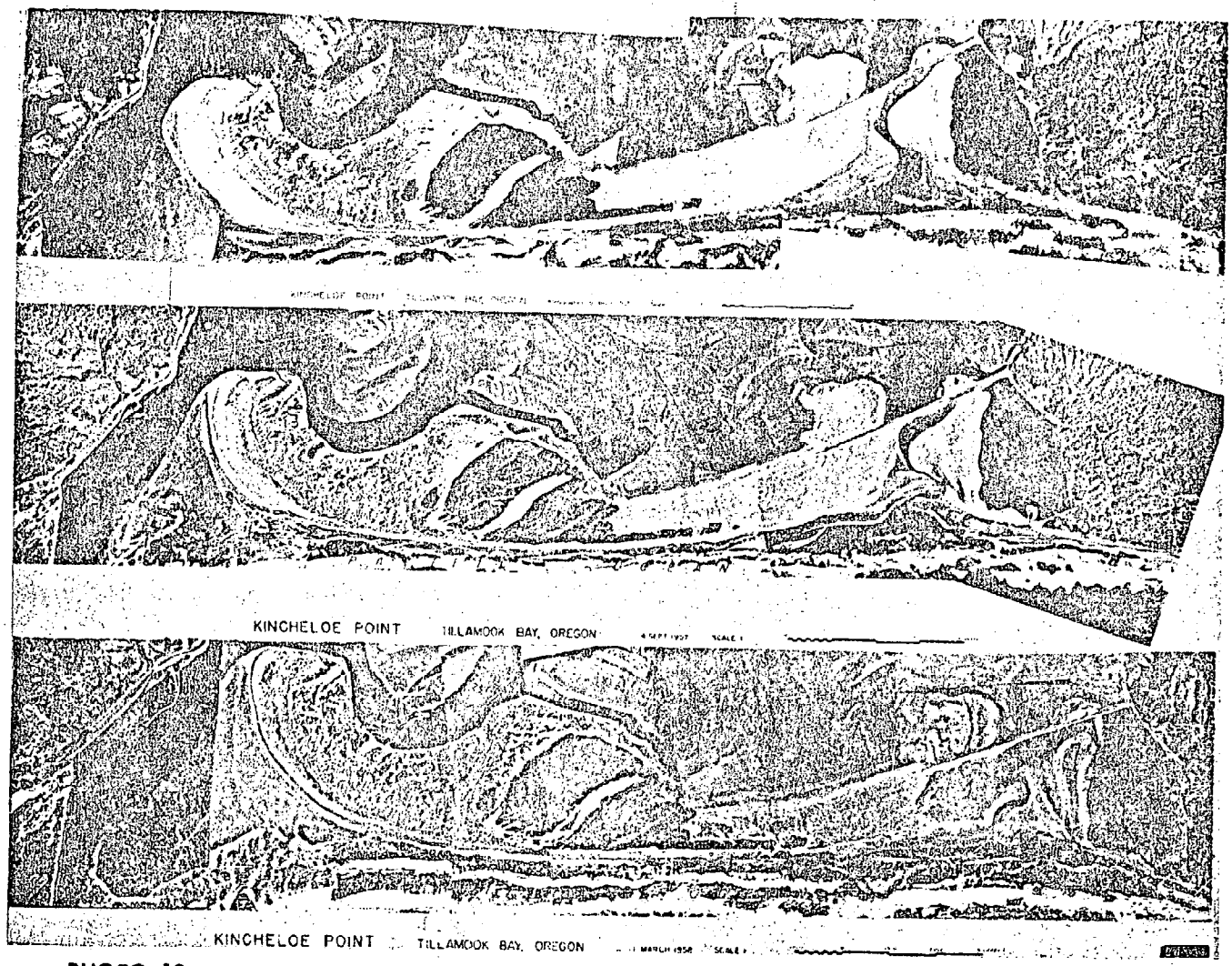


PHOTO 13. BAYOCEAN PENINSULA, TILLAMOOK BAY, OREGON - AERIAL PHOTOGRAPHS
1957 and 1958

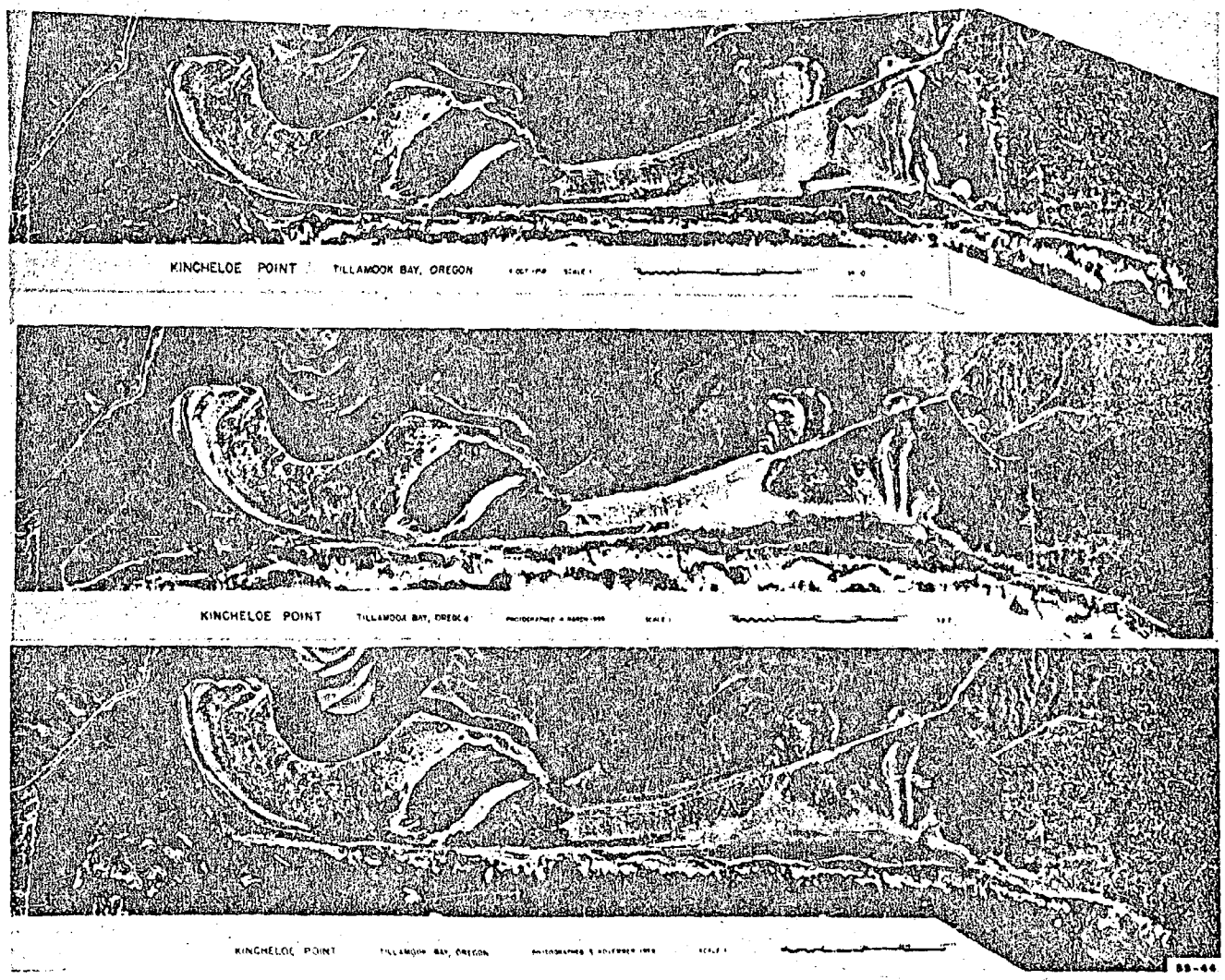


PHOTO 14. BAYOCEAN PENINSULA, TILLAMOOK BAY, OREGON - AERIAL PHOTOGRAPHS 1958 and 1959

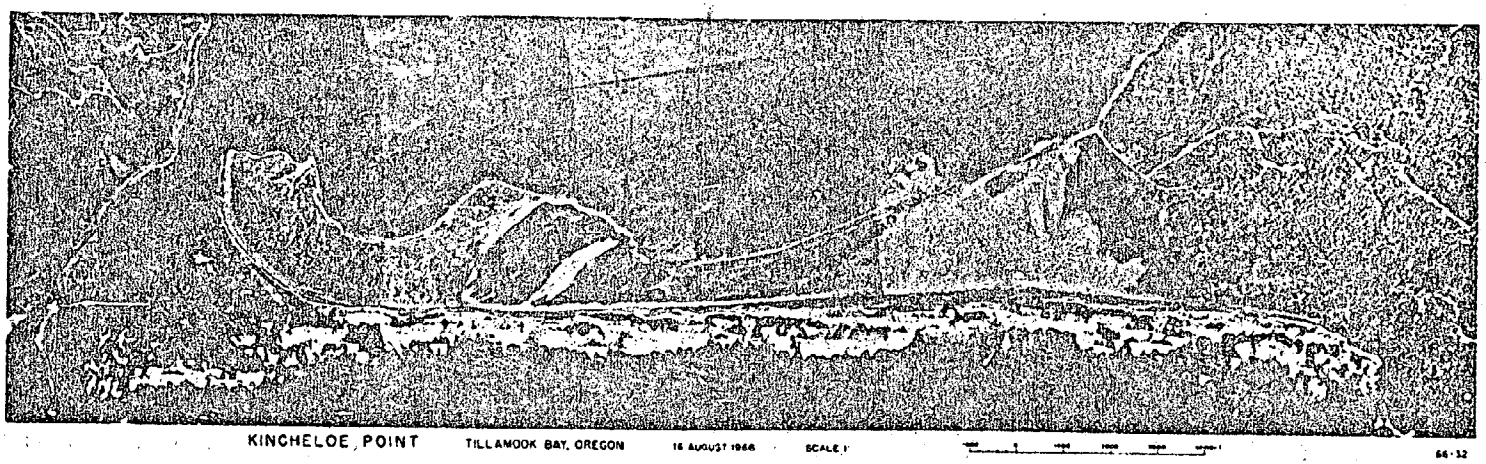


PHOTO 15. BAYOCEAN PENINSULA, TILLAMOOK BAY, OREGON - AERIAL PHOTOGRAPH
1966

foreshore sediments associated with waves from the northwest. Rapid accretion north of the north jetties at many of Oregon's river entrances is indicative of the predominant north-to-south littoral transport of sediment. More study is needed in connection with littoral drift prior to formulating plans for specific projects.

26. SHORE OWNERSHIP

A small amount of the upland adjacent to the line of ordinary high water in Oregon is owned by the Federal Government. The remainder is divided between State and local agencies and private individuals. Approximately 82.7 miles are Federally owned, 158 miles are owned by non-Federal public bodies, and 238 miles are privately owned. Ownership of the remaining 21.3 miles is uncertain.

The Oregon State Legislature has recognized that over the years the public has made frequent and uninterrupted use of lands abutting the shore of the Pacific Ocean, seaward of the natural vegetation line, for recreational purposes and that such use has been sufficient to create easements for the public through dedication, prescription, grant, or otherwise. Accordingly, the Legislative Assembly declared it to be in the public interest to protect and preserve public easement acquired through dedication, prescription, grant, or otherwise as a permanent part of Oregon's public recreational resources and to recognize and protect the rights of private owners to those lands that are not subject to public easements (ORS 390.605 et seq.). This legislation is commonly known as the "Beach Bill." The State Highway Commission has been delegated the authority to protect and preserve the rights of the public in the lands described in the Act.

27. SHORE USE

Development along the Oregon coast has for the most part been recreational in nature. The municipalities are generally oriented toward the tourist industry with resort-type development for the summer visitor. There should be a distinction drawn here between shore development and shore use. The term "development" implies an expenditure of capital and labor to provide improvement and facilities, however minimal they may be. However, use, and especially recreational use, can be and has been made of undeveloped land. About one-fifth of the Oregon shore has not been developed in any true sense, and much of the area listed herein as private recreational areas has little formal development. Notwithstanding the lack of development, where beaches exist and are accessible, the public has made use of the area for recreation--hiking, beachcombing, "cookouts," etc. That long historic usage is reflected in the legislation cited earlier. Along the Oregon coast, there are approximately 60 parks and recreational areas developed by Federal and State agencies, by individual counties, and by private power and timber companies. The areas range

from small reststop waysides along U.S. Highway 101 to parks encompassing several hundred acres. There are approximately 205.2 miles of shoreline which have been developed to some degree for public recreation. Of the remainder, about 81.3 miles are private recreation areas, 110 miles are developed for nonrecreational purposes, and 103.5 miles are undeveloped.

Residences, municipalities, businesses, and some light industry comprise nearly all of the activities along the developed bayshores. For the most part, the residences are dispersed and there are no densely populated areas. Forest products are the primary industry. A county park is located south of Umpqua River, and the sandspit at Nehalem Bay is part of a State park, but recreational development of the shores is quite minimal. Some recreational usage is made of the undeveloped areas despite the lack of facilities.

Residential development, both for summer occupancy and year-around use, is increasing. Many retired people, attracted by the moderate climate, are moving into coastal areas. Future development is expected to continue along much the same lines as in the past; however, increased residential development for year-round use and also some light industry may be expected.

28. AUTHORIZED FEDERAL PROJECTS

No Federal shore protection projects have been constructed in Oregon. However, numerous Federal navigation projects have been constructed. Table 9 lists the names, locations and pertinent data.

29. AUTHORIZED FEDERAL SURVEY STUDIES

Studies of beach-erosion problems along the Oregon coast have been limited to the Bayocean Peninsula at Tillamook Bay. A report titled "Report on Beach Erosion Studies, Tillamook Bay, Oregon, with Reference to Bayocean," dated 26 August 1940, was prepared by Portland District, Corps of Engineers. The District Engineer examined the feasibility of protecting Bayocean Peninsula against erosion. Among plans considered were construction of a south jetty, a system of groins, or constructing a new entrance to the bay at the south end of Cape Meares. Costs of all plans considered were much greater than the benefits to be derived and it was concluded that protective works were not justified.

30. ADDITIONAL STUDIES

There are approximately 64 miles of Oregon's shoreline where erosion is occurring which annually causes significant loss of land and which jeopardizes facilities and improvements costing millions of dollars. The areas threatened include homesites, park developments, highway facilities, and navigation channels. The erosion is occurring

TABLE 9

AUTHORIZED FEDERAL PROJECTS--OREGON

Name	Description	Status
Columbia River at the Mouth, Oreg. and Wash.	Channel dredging, north and south jetties, spur jetty on north shore	Complete
Columbia & Lower Willamette Rivers below Vancouver, Wash., Portland, Oreg.	Channel dredging; small-boat basin; breakwater at Astoria, Oreg.	Complete 1/
Skipanon Channel Oreg.	Channel and turning basin; dredging; mooring basin	Complete
Nehalem Bay, Oreg.	North and south jetties	Complete
Tillamook Bay & Bar, Oreg.	North and South jetties; channel dredging; mooring basin	South jetty under construction
Salmon River, Oreg.	Rock removal	Complete
Depoe Bay, Oreg.	Mooring basin; entrance channel dredging; breakwaters	Complete
Yaquina Bay & Harbor, Ore.	North and south jetties; bar and channel dredging; turning basin dredging; mooring basin; breakwater	South jetty extension under construction
Siuslaw River, Oreg.	North and south jetties; bar and channel dredging; turning basin dredging	Extension of north jetty authorized; construction deferred
Umpqua River, Oreg.	North and south jetties; bar and channel dredging; turning basin dredging; mooring basin	Complete
Coos Bay, Oreg.	North and south jetties; bar and channel dredging; turning and anchorage basins dredging; mooring basin; breakwater	Incomplete

1/That portion of the project within the estuarine zone.

Name	Description	Status
Coquille River, Oreg.	North and south jetties; channel dredging; snagging	Complete
Port Orford, Oreg.	Breakwater; channel dredging	Complete
Rogue River at Gold Beach, Oreg.	North and south jetties; channel and turning basin dredging	Complete
Chetco River, Oreg.	North and south jetties; Channel and turning basin dredging; small-boat access channel; dike	Complete

in many diverse locations and several separate projects would be required to alleviate all of the erosion problems. Due to the widespread location it is extremely difficult to quantify the studies which would be required.

31. OREGON COUNTIES

The 500 mile Cregon shoreline from the Washington border to the California border is briefly described and inventoried for Oregon's 7 counties with shoreline. While the shoreline processes do not recognize political boundaries, remedial action for controlling erosion likely would be accomplished by or through a local governmental body. County governments will also have valuable use for the inventory of their shorelines. A summary of county shoreline classification is shown on table 10. Sections of Oregon's shoreline are presented in plates 14 through 24. Physical characteristics and historic shore changes are classified on the "A" plates. Shore ownership and use are classified on the "B" plates.

CLATSOP COUNTY

Clatsop County (see plates 14 and 15) has a total of 59 miles of shoreline, including 36 miles along the Pacific Ocean and 23 miles along the estuaries of the Columbia and Necanicum Rivers. Except for a few rocky headlands, the ocean shore consists of sandy beaches. Astoria, about 14 miles above the mouth of the Columbia River, and Seaside, on the south side of the Necanicum River entrance, are the county's principal cities. About one-half the shore is used for recreational purposes and the balance is developed for various nonrecreational developments or is undeveloped.

The Oregon-Columbia River shore, consisting of the Clatsop sand spit at the mouth of Columbia River, blends into intertidal flats to the town of Hammond. Hammond, located on the shore, has a boat basin at the west end of the community. Farms are located farther inland. The shore from Hammond, around Youngs Bay, to the city of Astoria is intertidal. The area inland is flat, with numerous farms, the city of Warrenton, an airport, and numerous roads. Warrenton is accessible by boat through Skipanon Channel. Astoria, with all of its docks and industrial buildings, is the upstream limit of this shoreline study.

Critical erosion is occurring at Clatsop Spit, immediately south of the entrance to Columbia River, and on the north shore of the Necanicum River estuary. Along the ocean shore the uplands to the city of Gearhart are dunes, with some beach access roads and houses. The city of Gearhart is on the north side of Necanicum River, and the city of Seaside on the south side. Seaside is adjacent to the beach, and Gearhart is separated from the beach by a strip of foredune. Accretion south of the erosion area at Clatsop Spit is creating a

TABLE 10
COUNTY CLASSIFICATION - OREGON

COUNTY	LENGTH	PHYSICAL CHARACTERISTICS		HISTORICAL SHORE CHANGES			SHORELINE OWNERSHIP				SHORE USE			
	Miles of Shoreline	Shoreline with Beach	Shoreline without Beach	Critical Erosion	Noncritical Erosion	No Erosion	Federal	Public (Non-Federal)	Private	Uncertain	Recreational-Public	Recreational-Private	Nonrecreational Development	Undeveloped
CLATSOP	59.0	39.5	19.5	12.5	7.0	39.5	7.0	23.5	28.5	0	27.0	3.5	22.0	6.5
OCEAN	36.0	33.0	3.0	12.0	6.5	17.5	0	16.5	19.5	0	20.5	3.5	5.5	6.5
ESTUARY	23.0	6.5	16.5	0.5	0.5	22.0	7.0	7.0	9.0	0	6.5	0	16.5	0
TILLAMOOK	111.0	56.5	54.5	13.5	24.0	73.5	6.5	38.5	54.5	11.5	42.0	1.0	36.0	32.0
OCEAN	61.0	43.5	17.5	11.5	17.0	32.5	6.5	25.0	29.5	0	29.0	1.0	12.0	19.0
ESTUARY	50.0	13.0	37.0	2.0	7.0	41.0	0	13.5	25.0	11.5	13.0	0	24.0	13.0
LINCOLN	88.0	50.5	37.5	26.0	16.0	46.0	3.5	21.0	62.5	1.0	24.5	24.0	29.5	10.0
OCEAN	62.0	44.5	17.5	26.0	16.0	20.0	3.5	18.5	40.0	0	23.5	22.0	14.5	2.0
ESTUARY	26.0	6.0	20.0	0	0	26.0	0	2.5	22.5	1.0	1.0	2.0	15.0	8.0
LANE	40.0	31.0	9.0	3.5	7.5	29.0	18.5	11.0	10.5	0	17.0	11.0	0.5	11.5
OCEAN	32.0	25.0	7.0	0.5	7.0	24.5	15.5	9.0	7.5	0	16.0	11.0	0	5.0
ESTUARY	8.0	6.0	2.0	3.0	0.5	4.5	3.0	2.0	3.0	0	1.0	0	0.5	6.5
DOUGLAS	33.0	23.5	9.5	0	0	33.0	18.0	5.5	9.5	0	22.0	1.5	1.5	8.0
OCEAN	18.0	18.0	0	0	0	18.0	13.5	4.0	0.5	0	16.5	1.5	0	0
ESTUARY	15.0	5.5	9.5	0	0	15.0	4.5	1.5	9.0	0	5.5	0	1.5	8.0

TABLE 10
COUNTY CLASSIFICATION - OREGON

COUNTY	LENGTH	PHYSICAL CHARACTERISTICS		HISTORICAL SHORE CHANGES			SHORELINE OWNERSHIP				SHORE USE			
	Miles of Shoreline	Shoreline with Beach	Shoreline without Beach	Critical Erosion	Noncritical Erosion	No Erosion	Federal	Public (Non-Federal)	Private	Uncertain	Recreational-Public	Recreational-Private	Nonrecreational Development	Undeveloped
COOS	75.5	54.5	21.0	0	5.0	70.5	26.0	11.5	29.5	8.5	31.5	21.0	16.5	6.5
OCEAN	53.0	47.5	5.5	0	4.5	48.5	24.0	10.5	18.5	0	24.5	21.0	1.0	6.5
ESTUARY	22.5	7	15.5	0	0.5	22.0	2.0	1.0	11.0	8.5	7.0	0	15.5	0
CURRY	93.5	44.5	49.0	8.5	42.0	43.0	3.2	47.0	43.0	0.3	41.2	19.3	4.0	29.0
OCEAN	90.0	44.5	45.5	8.5	41.5	40.0	3.0	45.0	42.0	0	41.0	19.0	1.0	29.0
ESTUARY	3.5	0	3.5	0	0.5	3.0	0.2	2.0	1.0	0.3	0.2	0.3	3.0	0
TOTALS OREGON STATE	500.0	300.0	200.0	64.0	101.5	334.5	82.7	158.0	238.0	21.3	205.2	81.3	110.0	103.5

problem for the city of Seaside. Several years ago the city constructed a seawall, about 1.5 miles in length, fronting the main business district. A promenade and a city street are located adjacent to the seawall. Sand builds up on the beach, overtops the seawall, and covers the promenade and street, necessitating costly removal work. U.S. Highway 101 runs parallel to the shoreline and east of Gearhart and Seaside. South from Seaside to Cannon Beach the shore is a steep, rocky headland. U.S. Highway 101 crosses the headland several miles inland. From the headland to the Clatsop-Tillamook county line, the beach is narrow. Adjacent towns are Cannon Beach, Tolovana Park, and Arch Cape. Between these communities the terrain consists of low hills and rocky points. U.S. Highway 101 runs generally adjacent and parallel to the shoreline.

A Federal navigation project at the mouth of Columbia River provides for two rubblemound jetties, a spur jetty on the north shore, and an entrance channel 48 feet deep and one-half mile wide. A navigation channel 40 feet deep by 600 feet wide extends upstream in Columbia River from river mile 3 to river mile 105.5. There is no Federal project at Necanicum River.

TILLAMOOK COUNTY

Tillamook County (see plates 14, 16 and 18) has 61 miles of shoreline on the Pacific Ocean, consisting of sandy beaches interspersed with rocky headlands and nonbeach areas. There are four bays and estuaries with 50 miles of shoreline within the county. Listed from north to south they are: Nehalem Bay, Tillamook Bay, Netarts Bay, and Nestucca Bay. Tillamook Bay (see plate 17), one of Oregon's larger estuaries, is a popular sport fishing area and supports a significant oyster industry. Tillamook and Garibaldi, at the south and north ends of Tillamook Bay, respectively, are the county's largest cities. Almost one-third of the shoreline is essentially undeveloped, and the remainder is nearly equally divided between recreational and nonrecreational developement. Critical erosion is occurring along Bayocean Peninsula, a natural barrier beach separating Tillamook Bay and the Pacific Ocean, on both the ocean and bay sides. Other areas along the county's shoreline are experiencing both critical and noncritical erosion. A total of about 2 miles of shoreline in Nehalem, Netarts, and Nestucca Bays have minor noncritical erosion problems.

The northern limit of Tillamook County is a headland known as Neahkahnie Mountains. The shoreline consists of high, steep cliffs. The area is wooded and undeveloped, with the exception of Oswald West State Park. The headland ends near the community of Neahkahnie. The shoreline is a narrow beach, passing through the city of Mansanita, and blending into a wide beach on the Nehalem peninsula. South of Nehalem River the wide sandy beach continues to the Tillamook Bay entrance, passing through the communities of Brighton, Manhattan Beach, Rockaway, and Barview. The towns are located at the foot of the

mountains and on the foredune area adjacent to the beach. U.S. Highway 101 runs generally along the east of all these communities, with the exception of Rockaway, where the highway passes through the center of town. Between Bayocean Peninsula, at Tillamook Bay, and Netarts Spit the shoreline consists of steep cliffs and narrow beaches. The uplands are wooded mountains, low hills, and high foredunes. The towns of Oceanside and Netarts lie just north of Netarts Spit on low hills adjacent to the narrow beach zone. Here U.S. Highway 101 lies several miles upland and runs through the city of Tillamook. It leaves the shore at Bay City and returns near the community of Neskowin. Just south of Netarts Spit, Cape Lookout protrudes into the ocean. It is mountainous and wooded, with steep cliffs, and is undeveloped except for Cape Lookout State Park. Cascade Head, just south of the town of Neskowin, is another prominent feature similar to Cape Lookout. Between these features the shoreline is a sandy beach with one prominent rock point. The uplands are low, hilly foredunes. Dunes are a prominent feature near Pacific City. Other communities near the shore are Tierra Del Mar, Woods, and Neskowin. U.S. Highway 101 lies inland from Neskowin to Lincoln County in Lincoln County. The land is virtually undeveloped, with the exception of a few residences located between communities.

There are Federal navigation projects at Nehalem Bay and at Tillamook Bay. The project at Nehalem provides for two rubblemound jetties at the entrance. The project at Tillamook Bay also provides for two rubblemound jetties at the entrance; the south jetty is currently under construction. In addition, the Tillamook Bay project provides for an entrance channel 18 feet deep and of suitable width; a bay channel 18 feet deep and 200 feet wide, to a turning basin near Garibaldi; and a small-boat basin at Garibaldi. The sand-and-rockfill dike constructed to close the breach in Bayocean Peninsula was authorized in the interest of navigation.

LINCOLN COUNTY

Lincoln County's Pacific Ocean shoreline (see plates 18 and 19) is much like that of Clatsop and Tillamook Counties to the north--sandy beaches broken by rocky headlands and inlets. The northern limit of Lincoln County is Cascade Head at Salmon River. It blends into a narrow beach, bordered by the highly populated city of Lincoln City, and extends to Lincoln Beach, just north of Depoe Bay. From this point to Otter Rock the terrain is mountainous with rocky, steep cliffs. U.S. Highway 101 generally follows the shoreline. There are scattered residences between the shoreline and the highway. Between Otter Rock and Yaquina Head the shore is a narrow, sandy beach bordered by foredunes, some residential areas, and U.S. Highway 101. Yaquina Head is a bare rock protrusion with steep cliffs on which the community of Agate Beach is located. The beach, to the Yaquina Bay entrance, is narrow and bordered by residences and the city of Newport.

From Yaquina Bay entrance south to the city of Waldport, the shoreline is a sandy beach bordered by residential areas, foredunes, and U.S. Highway 101. From this point south to the Lincoln County line the shoreline is rocky, with steep cliffs. The upland is mountains, primarily undeveloped, with the exception of U.S. Highway 101 and a few residences.

About 70 percent of the county's 62 miles of ocean shore is classified as beach zone. Siletz Bay, Yaquina Bay, and Alsea Bay, the principal estuaries in Lincoln County, have a total of 26 miles of shoreline. Newport, at Yaquina Bay; Lincoln City; and Waldport, at Alsea Bay, are the county's largest cities in the coastal portion. Nearly three-fourths of the county's ocean shoreline is used for recreational purposes but only about 3 miles of the total estuarine shore are used for recreation. About 26 miles of the ocean shore are undergoing critical erosion, and an additional 16 miles are suffering minor erosion.

A Federal navigation project at Yaquina Bay provides for two rubblemound jetties at the entrance, a 40-foot by 400-foot entrance channel, and a bay channel 30 feet deep by 300 feet wide. An extension to the south jetty is currently under construction. A small-boat basin is included in the project at Yaquina Bay, and a small-boat basin at Alsea Bay is authorized but unconstructed.

LANE COUNTY

Lane County is one of the larger counties in the state; however, it has only 40 miles of shoreline, of which 32 miles are along the Pacific Ocean (see plate 21). The northern portion of the ocean shoreline consists of sandy beaches cut by rocky headlands. The southern portion of the shoreline is composed of low, continuous sand beaches, interrupted only by small streams.

The Lane County shoreline is rocky from its northern beginning to Tenmile Creek. The upland is mountainous, and contains Highway 101 and some residences, mostly undeveloped. From Tenmile Creek to Devils Elbow State Park the shoreline is sandy beach and small rock projections. The upland is foredune, containing Highway 101 and some residences. Devils Elbow State Park is a wooded, rocky headland with steep cliffs. This same general feature extends just south of Sea Lion Caves. Highway 101 follows the shore and, except for a few residences, the area is undeveloped. The shoreline to the Douglas County line consists of wide beaches and dunes upland. There is one small community just north of the Siuslaw River entrance.

Siuslaw River, the only estuary of note within Lane County, has 8 miles of shoreline (see plate 21). The city of Florence, about 5 miles upstream of the mouth of the Siuslaw, is the largest community

in the coastal portion of the county. About 0.5 mile of Pacific Ocean shore and about 3 miles of the shore in the Siuslaw River estuary have critical erosion. Recreation is the primary use made of Lane County's shoreline. A Federal navigation project at Siuslaw River provides for two rubblemound jetties at the entrance, an entrance channel 18 feet deep by 300 feet wide, and a 16-foot by 200-foot river channel. Extension of the north jetty has been authorized but not constructed.

DOUGLAS COUNTY

Douglas County has the shortest shoreline of the 7 coastal counties--33 miles long, including 18 miles of ocean shore and 15 miles of estuarine shore (see plate 20). Like the southern portion of Lane County, the ocean shoreline is comprised of continuous, low-lying, sandy beaches cut by small streams and by the Umpqua River, the only major estuary in the county. Inland from the beaches the area consists of large sand dunes. Reedsport, located on Umpqua River, is the only major city in the coastal portion of Douglas County. Most of the shoreline is beach zone used for recreational purposes. The Siuslaw National Forest and a State park account for the fact that nearly 75 percent of the shoreline is in public ownership. There is no critical erosion within the county. A Federal navigation project at Umpqua River provides for two rubblemound jetties, an entrance 26 feet deep with no specific width, a 22-foot by 200-foot river channel, and a small-boat basin.

COOS COUNTY

Coos County (see plates 22 and 23) has 75.5 miles of shoreline, of which 53 miles are along the Pacific Ocean. From the Douglas-Coos County line to the entrance to Coos Bay, Coos County's shoreline is low sandy beaches. South of Coos Bay the shoreline is composed of low cliffs and narrow sand beaches. About 70 percent of the shore is considered to be beach zone.

Coos County features wide beaches and dunes upland, undeveloped except for recreational areas, to the Coos Bay entrance. South of the entrance the terrain is mountainous, steep cliffs, with some residences and a road to Cape Arago. The area, the major portion of which is undeveloped, blends into more gentle slopes with narrow beaches to Twomile Creek. Between Twomile Creek and the Coquille River entrance, the beaches are wider and the uplands are dunes. From the Coquille entrance the shore has short, narrow beaches and rocky projections, with numerous houses and an access road upland to China Creek. South of China Creek to the county line the beaches are wide and the uplands are dunes, mostly undeveloped. Featured is Croft Lake adjacent to the shore. U.S. Highway 101 generally parallels the shoreline about 1-1/2 miles inland, except at Coos Bay where the highway runs several miles inlnad through the cities of Coos Bay and North Bend.

Coos Bay and North Bend, both located on Coos Bay, and Bandon, at Coquille River, are the largest cities in the coastal section of the county. Coos Bay and Coquille River, the principal estuaries in Coos County, have 22.5 miles of shoreline. There are few erosion problems in Coos County; only about 5 miles are experiencing noncritical erosion. About 30 percent of the total shoreline is developed for nonrecreational purposes. Slightly more than 10 percent is undeveloped, and the balance is used for recreational purposes. With the exception of Columbia River, Coos Bay is the largest estuary on the Oregon coast, and the port is a very active shipping center for forest products and other commodities. A recently authorized but unconstructed modification to the navigation project at Coos Bay provides for a 45-foot by 700-foot entrance channel and a 35-foot by 300- to 400-foot bay channel. In addition, the project provides for two rubblemound jetties at the entrance and a small-boat basin near the entrance. The project at Coquille River provides for two rubblemound jetties and a channel 13 feet deep with no specific width.

CURRY COUNTY

Curry County has 93.5 miles of shoreline, 90 miles along the Pacific Ocean and 3.5 miles along the Rogue and Chetco River estuaries (see plates 23 and 24). North of Cape Blanco the shoreline is dominated by marine terraces with low cliffs and narrow, sand beaches. Cliffs and small embayments characterize the shoreline south of Cape Blanco. The narrow beaches in that area are composed of coarse sands and gravels. About one-half of the total shoreline is considered beach zone.

Between the Coos-Curry county line and the Floras Lake the beaches are wide and the uplands are dunes. South of Floras Lake to Cape Blanco the area is a rocky headland with steep cliffs and some narrow beaches. From Cape Blanco (through Port Orford) the beach is narrow with mountainous uplands, partially developed with residences. Between Port Orford and Brookings, the area is mountainous and rocky with steep cliffs and sand beaches. From Brookings the coast is flat, with some beach, and the upland is agricultural with many farms to the Oregon-California border. U.S. Highway 101 parallels the shoreline and is located about 3 miles inland from the Coos-Curry county line to Port Orford. Between Port Orford and the Oregon-California border the highway is generally located adjacent to the shore.

Brookings, at the mouth of Chetco River; Gold Beach, at the mouth of Rogue River; and Port Orford are the county's main cities. Approximately 10 percent of the county's shoreline is experiencing critical erosion. About one-third of the shore is undeveloped and much of the balance is relatively undeveloped but is used for recreation. There are three Federal navigation projects in the county--Port Orford, Rogue River, and Chetco River. The project at Port Orford provides for a breakwater and channel maintenance. At Rogue River, a channel

13 feet deep by 300 feet wide and two rubblemound jetties are authorized. A survey study is in progress to determine if any modification to the project at Rogue River is justified. The project at Chetco River provides for two rubblemound jetties, a channel 14 feet by 120 feet, and a small-boat basin.

31. COST SUMMARY OF CONCEPTUAL PLANS FOR CRITICAL EROSION AREAS

Table 11 gives a cost summary by county of the conceptual plans for controlling critical erosion in Oregon.

☆U.S. GOVERNMENT PRINTING OFFICE: 1971—999-341

TABLE 11
COST SUMMARY OF CONCEPTUAL PLANS FOR SUITABLE PROTECTION - 1970
OREGON

County (Critical erosion area)	Suitable projection	Length (miles)	Total cost
Clatsop			
(Ocean)	Beach nourishment	9.0	$6,750,000
(Clatsop Spit)	Beach nourishment	3.0	2,250,000
(Necanicum River)	Beach nourishment	0.5	125,000
Tillamook			
(Ocean)	Beach nourishment	7.5	5,625,000
(Bayocean Peninsula)	Beach nourishment	6.0	2,250,000
Lincoln			
(Ocean)	Beach nourishment	23.0	17,250,000
(Ocean)	Revetment	3.0	2,250,000
Lane			
(Ocean)	Pile groins & revetment	3.0	600,000
(Siuslaw River)	Revetment	0.5	375,000
Curry			
(Ocean)	Beach nourishment	5.0	3,750,000
(Ocean)	Revetment	3.5	2,625,000
TOTAL		64.0	$43,850,000

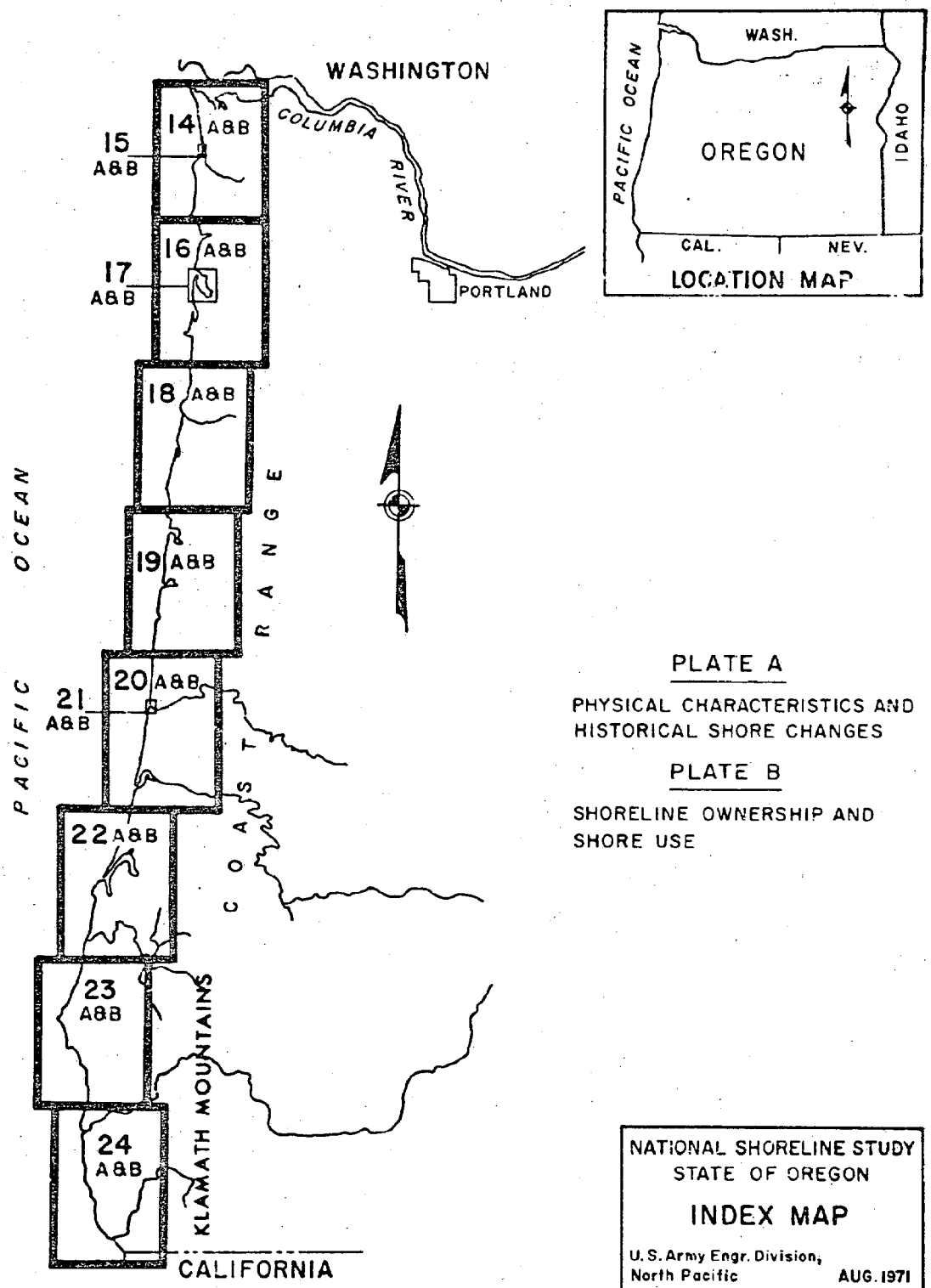


PLATE A

PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

PLATE B

SHORELINE OWNERSHIP AND SHORE USE

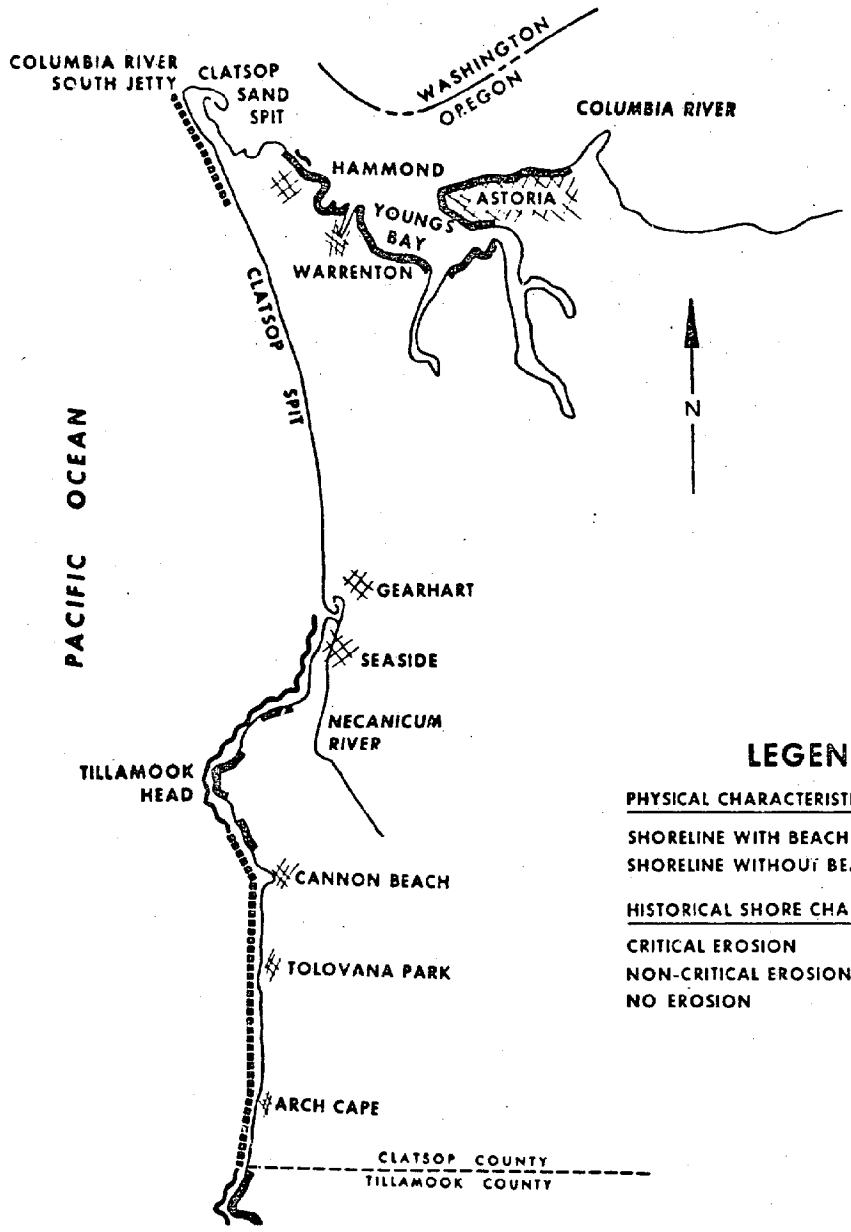
NATIONAL SHORELINE STUDY
STATE OF OREGON

INDEX MAP

U.S. Army Engr. Division, North Pacific AUG. 1971

File No. PD-26-5/1

PLATE 13



LEGEND

PHYSICAL CHARACTERISTICS (Landward)

SHORELINE WITH BEACH	No Symbol
SHORELINE WITHOUT BEACH	▬▬

HISTORICAL SHORE CHANGES (Seaward)

CRITICAL EROSION	▪▪▪▪▪▪
NON-CRITICAL EROSION	~~~
NO EROSION	No Symbol

SCALE IN MILES

5 0 1 2 3 4 5

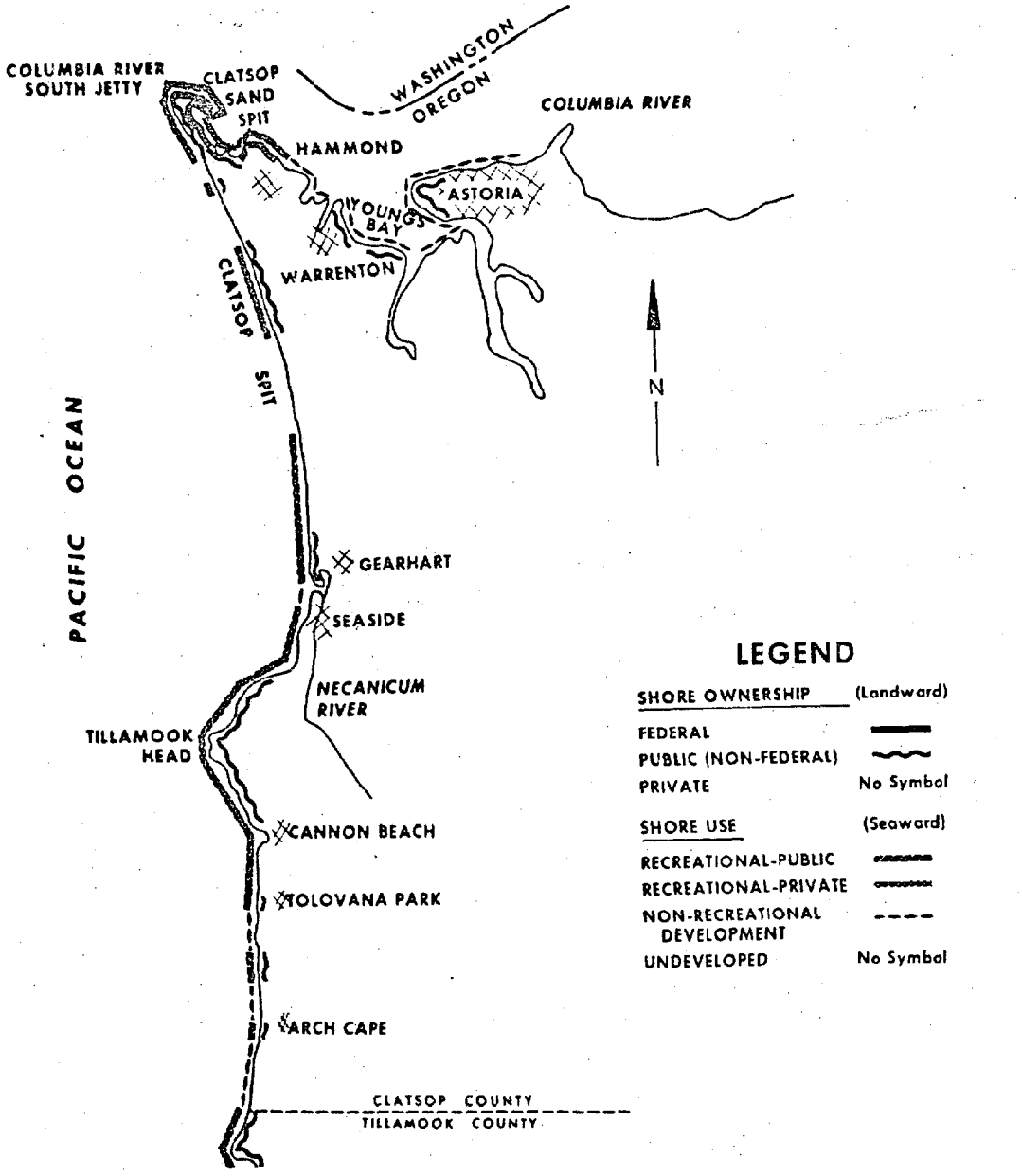
NATIONAL SHORELINE STUDY
STATE OF OREGON

PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. PD-26-5/2

PLATE 14A



LEGEND

SHORE OWNERSHIP	(Landward)
FEDERAL	
PUBLIC (NON-FEDERAL)	
PRIVATE	No Symbol
SHORE USE	(Seaward)
RECREATIONAL-PUBLIC	
RECREATIONAL-PRIVATE	
NON-RECREATIONAL DEVELOPMENT	
UNDEVELOPED	No Symbol

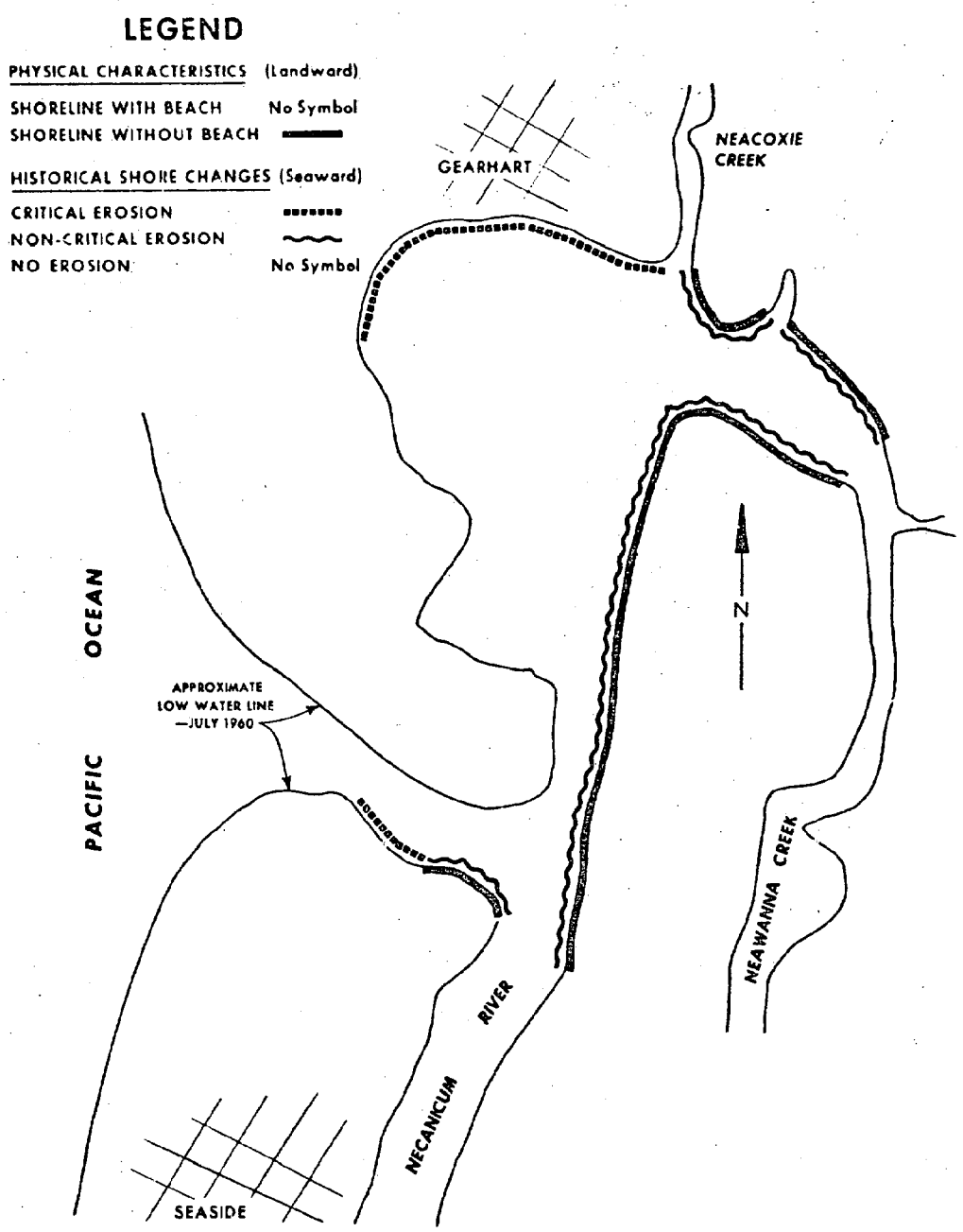
NATIONAL SHORELINE STUDY
STATE OF OREGON

SHORE OWNERSHIP AND SHORE USE

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. PD-26-5/3

PLATE 14B



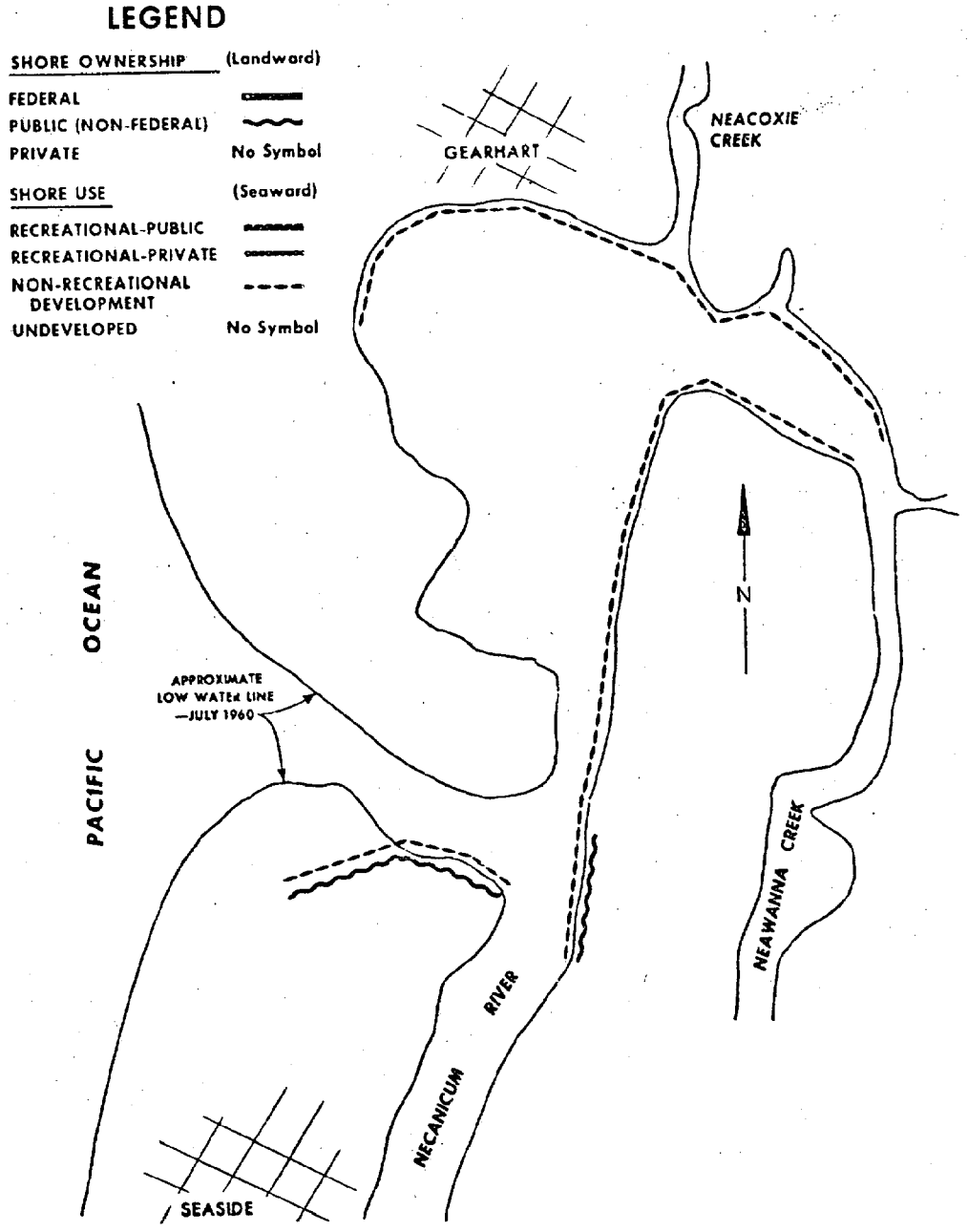
NATIONAL SHORELINE STUDY
STATE OF OREGON

PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. PD-26-5/4

PLATE 15A



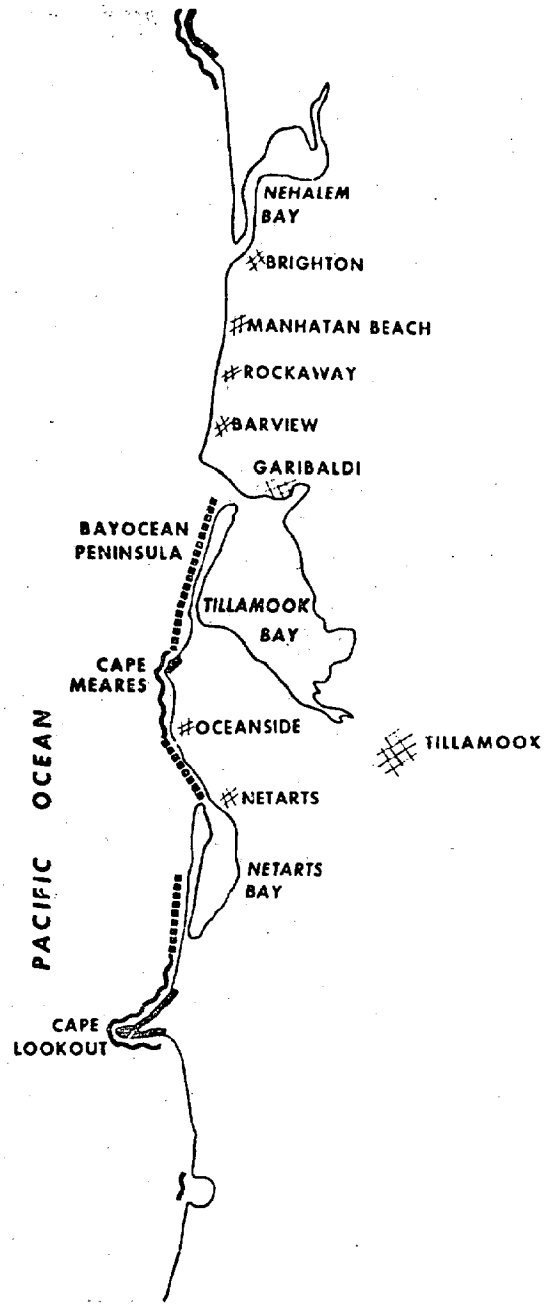
NATIONAL SHORELINE STUDY
STATE OF OREGON

SHORE OWNERSHIP AND SHORE USE

U S Army Engr Division, North Pacific Aug. 1971

File No. PD-26-5/5

PLATE 15B



N

LEGEND

PHYSICAL CHARACTERISTICS (Landward)	
SHORELINE WITH BEACH	No Symbol
SHORELINE WITHOUT BEACH	▬▬
HISTORICAL SHORE CHANGES (Seaward)	
CRITICAL EROSION	▪▪▪▪▪▪▪
NON-CRITICAL EROSION	∿∿∿
NO EROSION	No Symbol

SCALE IN MILES

5 0 1 2 3 4 5

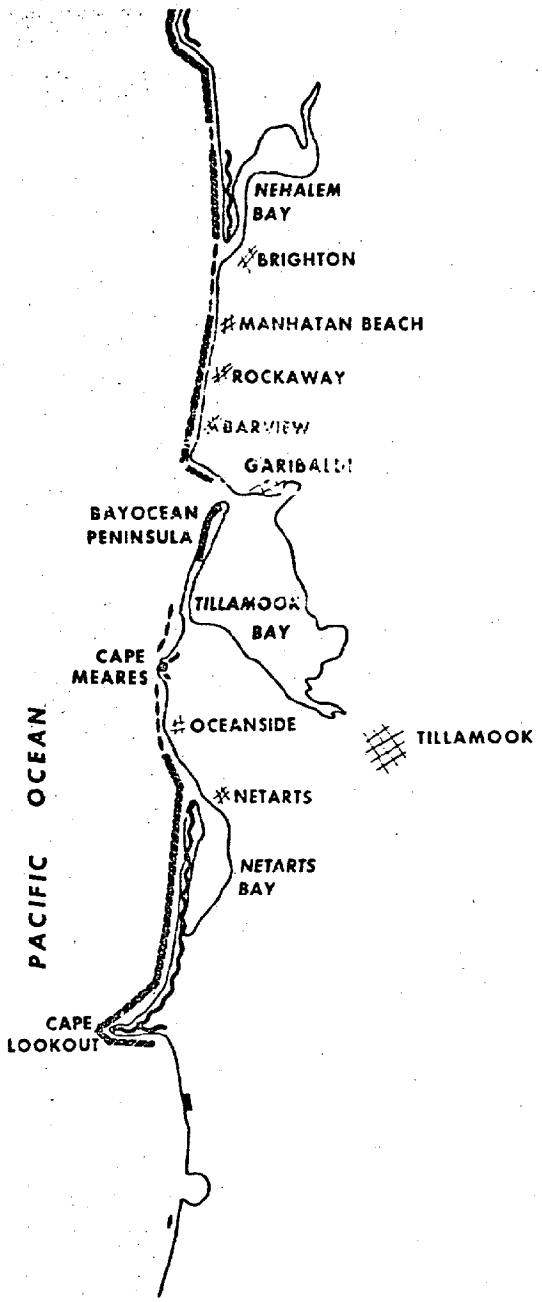
NATIONAL SHORELINE STUDY
STATE OF OREGON

PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. PD-26-5/6

PLATE 16A



N

LEGEND

SHORE OWNERSHIP	(Landward)
FEDERAL	
PUBLIC (NON-FEDERAL)	
PRIVATE	No Symbol
SHORE USE	**(Seaward)**
RECREATIONAL-PUBLIC	
RECREATIONAL-PRIVATE	
NON-RECREATIONAL DEVELOPMENT	
UNDEVELOPED	No Symbol

SCALE IN MILES

5 0 1 2 3 4 5

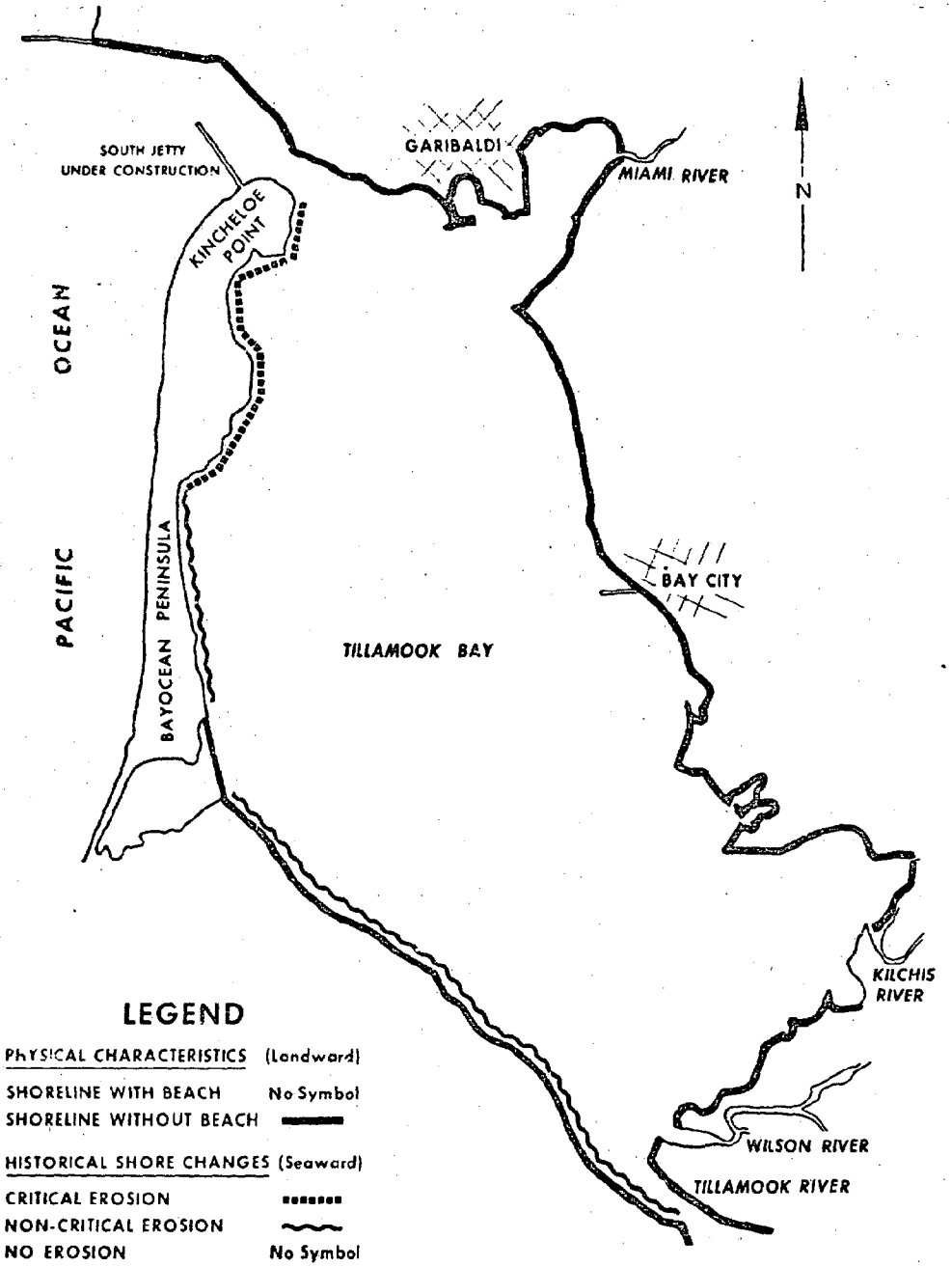
NATIONAL SHORELINE STUDY
STATE OF OREGON

SHORE OWNERSHIP AND SHORE USE

U.S. Army Engr. Division, North Pacific Aug. 1971

File No: PD-26-5/7

PLATE 16B



LEGEND

PHYSICAL CHARACTERISTICS (Landward)	
SHORELINE WITH BEACH	No Symbol
SHORELINE WITHOUT BEACH	▬▬
HISTORICAL SHORE CHANGES (Seaward)	
CRITICAL EROSION	▪▪▪▪▪▪▪
NON-CRITICAL EROSION	~~~~
NO EROSION	No Symbol

SCALE IN MILES

1 ½ 0 1

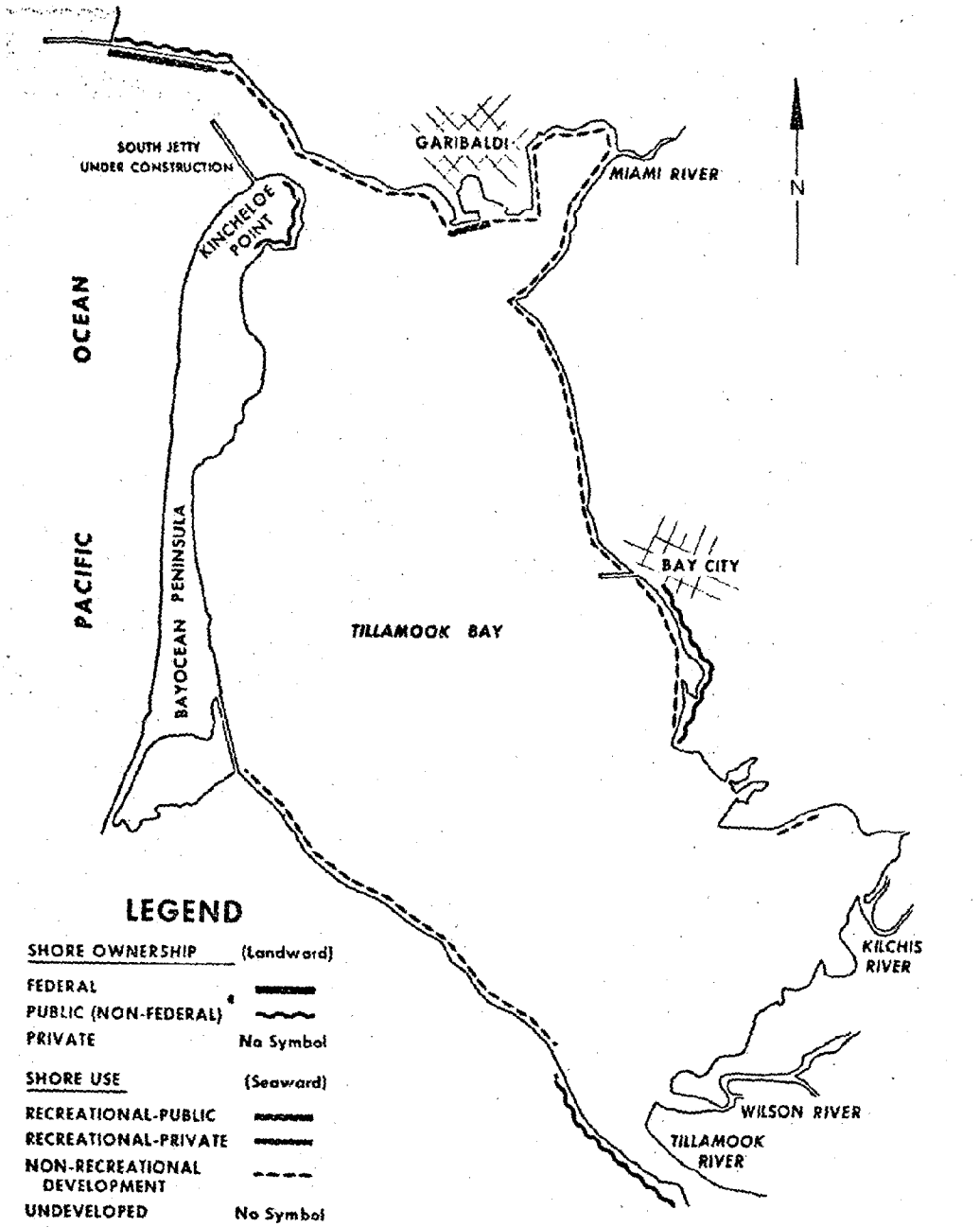
NATIONAL SHORELINE STUDY
STATE OF OREGON

PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. PD-26-5/8

PLATE 17A



LEGEND

SHORE OWNERSHIP	(Landward)
FEDERAL	
PUBLIC (NON-FEDERAL)	
PRIVATE	No Symbol
SHORE USE	**(Seaward)**
RECREATIONAL-PUBLIC	
RECREATIONAL-PRIVATE	
NON-RECREATIONAL DEVELOPMENT	
UNDEVELOPED	No Symbol

SCALE IN MILES

1 ½ 0 1

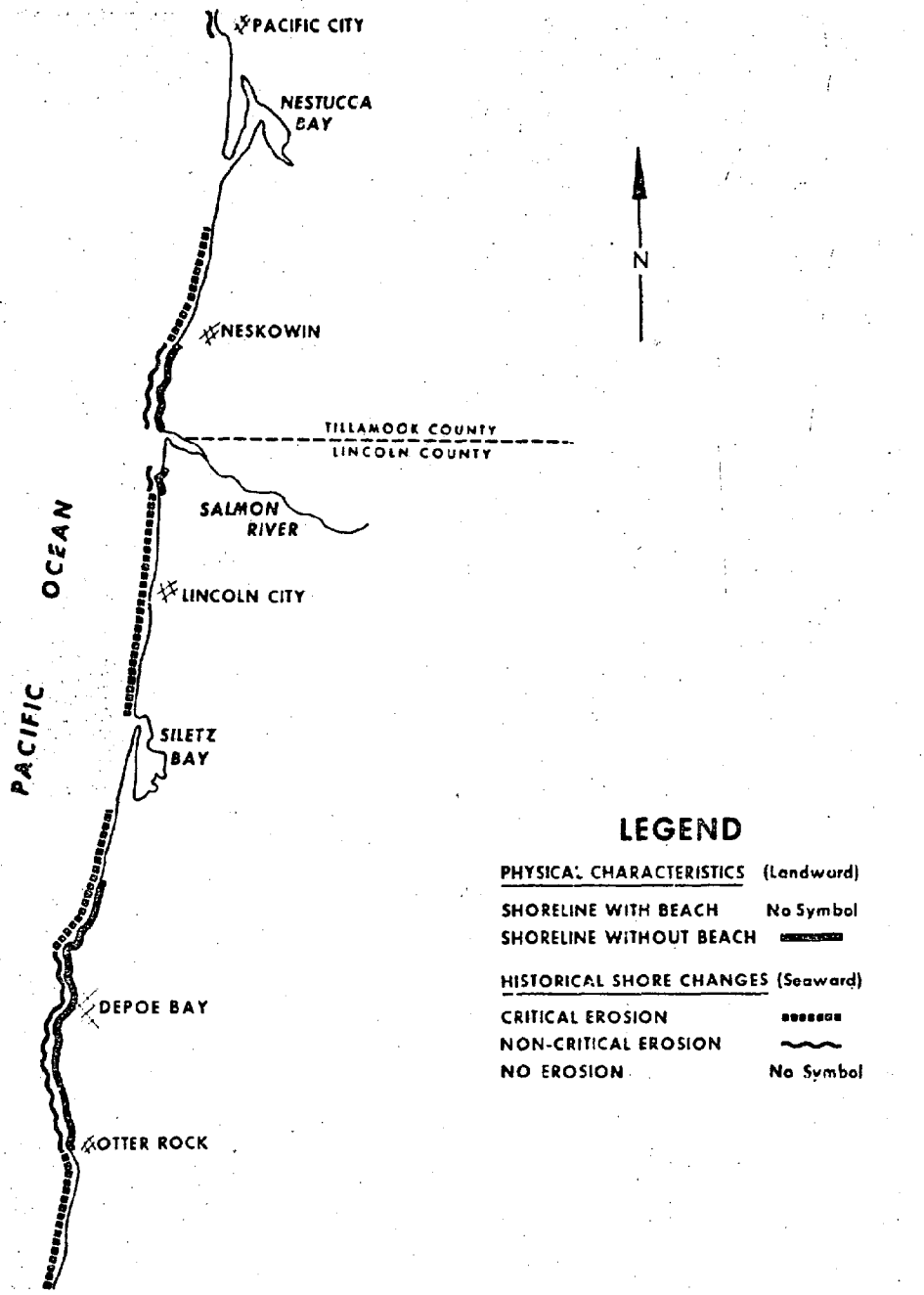
NATIONAL SHORELINE STUDY
STATE OF OREGON

SHORE OWNERSHIP AND SHORE USE

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. PD-26-5/9

PLATE 17B



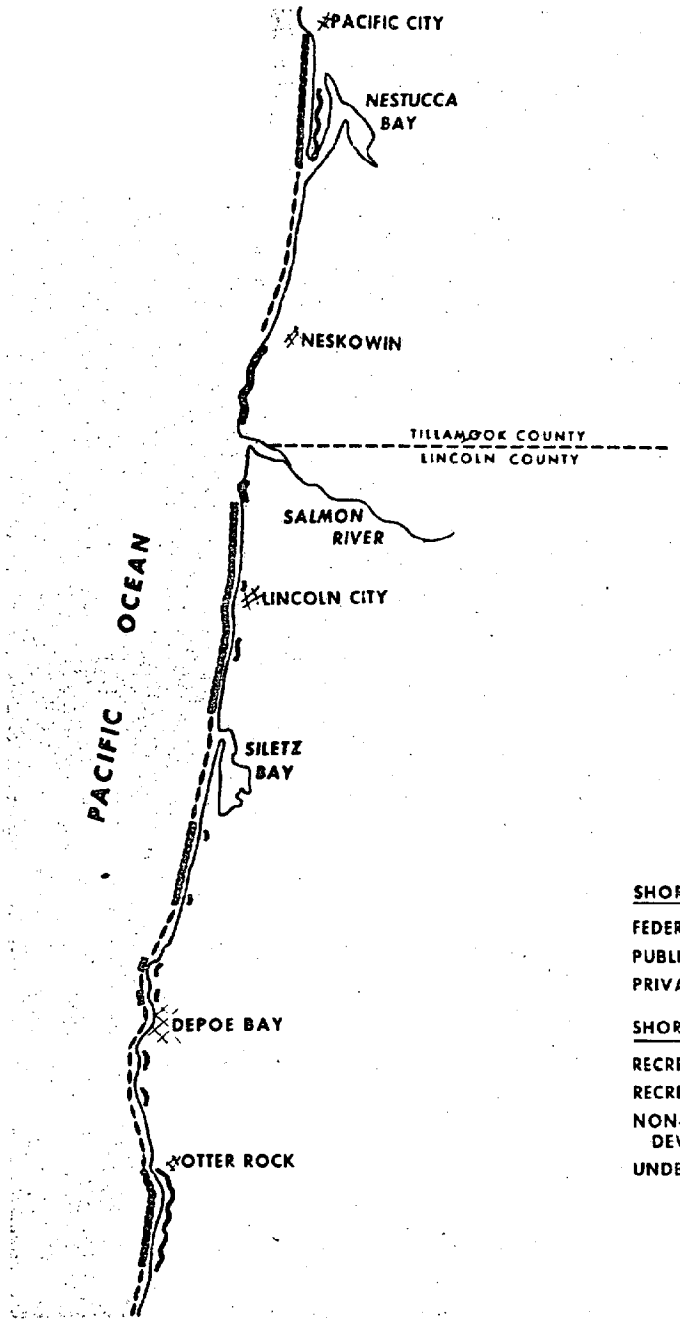
NATIONAL SHORELINE STUDY
STATE OF OREGON

PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. PD-26-5/10

PLATE 18A



LEGEND

SHORE OWNERSHIP	(Landward)
FEDERAL	
PUBLIC (NON-FEDERAL)	
PRIVATE	No Symbol
SHORE USE	(Seaward)
RECREATIONAL-PUBLIC	
RECREATIONAL-PRIVATE	
NON-RECREATIONAL DEVELOPMENT	
UNDEVELOPED	No Symbol

SCALE IN MILES

5 0 1 2 3 4 5

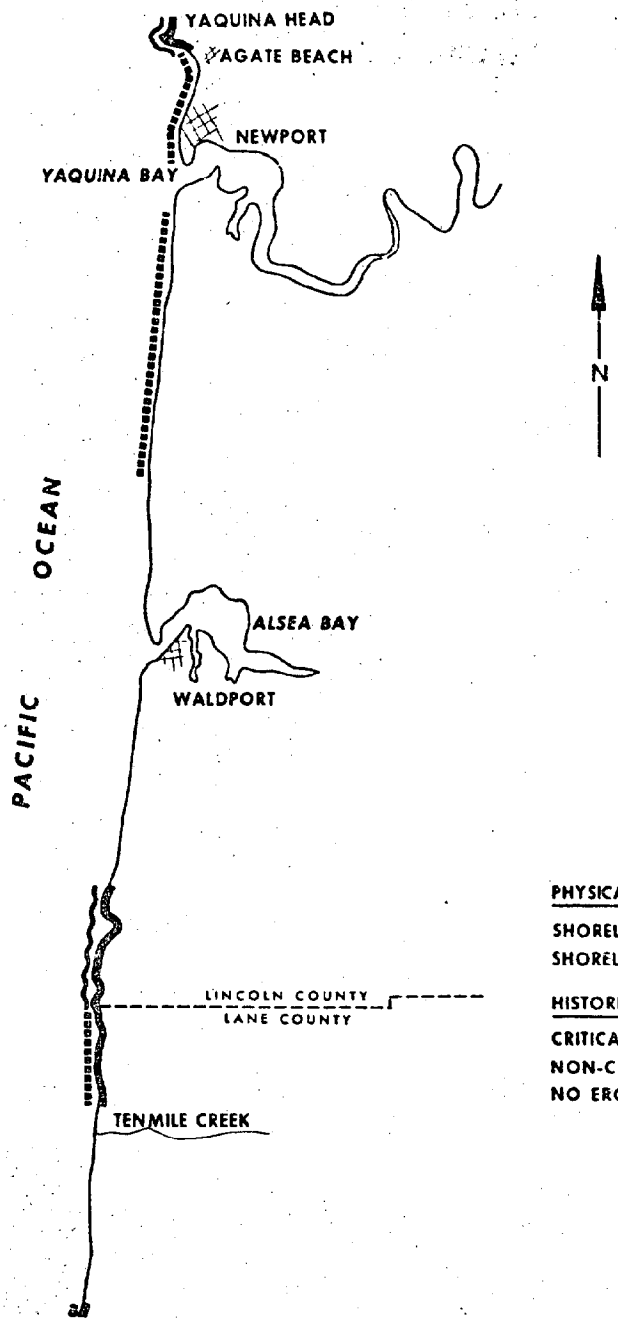
NATIONAL SHORELINE STUDY
STATE OF OREGON

SHORE OWNERSHIP AND SHORE USE

U.S. Army Engr Division, North Pacific Aug. 1971

File No. PD-26-5/11

PLATE 185



LEGEND

PHYSICAL CHARACTERISTICS (Landward)

SHORELINE WITH BEACH	No Symbol
SHORELINE WITHOUT BEACH	▬▬

HISTORICAL SHORE CHANGES (Seaward)

CRITICAL EROSION	▪▪▪▪▪▪
NON-CRITICAL EROSION	~~~
NO EROSION	No Symbol

SCALE IN MILES

5 0 1 2 3 4 5

NATIONAL SHORELINE STUDY
STATE OF OREGON

PHYSICAL CHARACTERISTICS AND HISTORICAL SHORE CHANGES

U.S. Army Engr. Division, North Pacific Aug. 1971

File No. PD-26-5/12

PLATE 19A